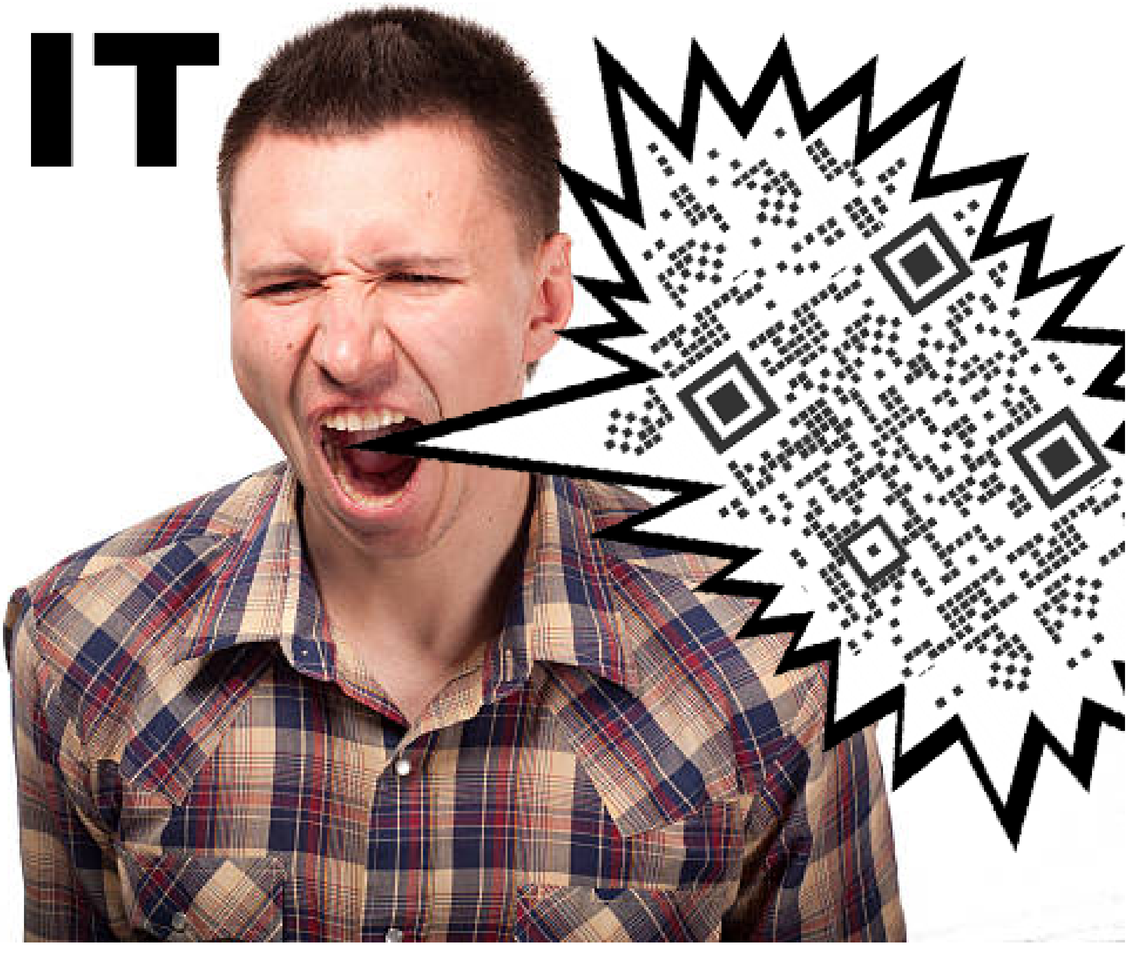
SHOUT
SHARE **IT**



[illegible] 4456

HARVARD UNIVERSITY.

LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY.

12,974

Exchange

October 1. 1895 — October 1. 1897

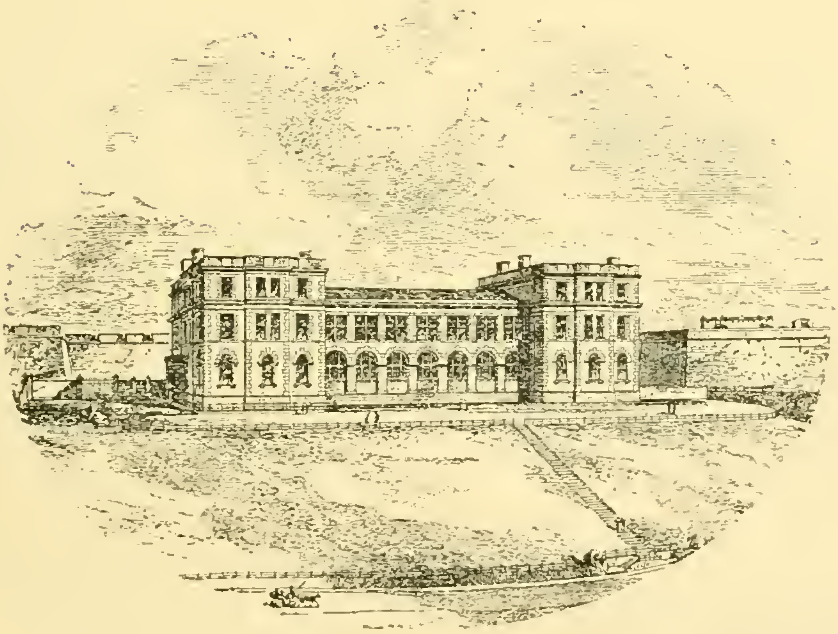
Journal

OF THE

MARINE BIOLOGICAL ASSOCIATION

OF

THE UNITED KINGDOM.



VOLUME IV. (N.S.).

1895-97.

PLYMOUTH:
PUBLISHED BY THE ASSOCIATION.

Agents in London:—Messrs. DULAU & Co., 37, Soho Square, W.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for the accuracy of statements published in this Journal, excepting when those statements are contained in an official report of the Council.

OCT 1 1897

CONTENTS OF VOLUME IV.

(NEW SERIES.)

PAGE

Title i

Contents iii

List of Governors, Founders, and Members—

August, 1896 308

Report of Council—

1894–95 81

1895–96 302

Director's Report—

August, 1895 76

January, 1896 219

August, 1896 300

February, 1897 415

Allen, E. J.

Faunistic Notes—

January to June, 1895 48

Notes on Dredging and Trawling Work during the latter half of 1895 164

The Reproduction of the Lobster 60

Additional Observations on the Nerve-elements of the Embryonic Lobster 70

Report on the Sponge Fishery of Florida and the Artificial Culture of Sponges 188

Supplement 289

The Protection of Crabs and Lobsters 182

The Regulations of the Local Sea Fisheries Committees in England and Wales 386

Bassett-Smith, P. W.

A List of the Parasitic Copepoda of Fish obtained at Plymouth . . 155

Bethe, A.

A Carcinus with a Right-handed Walking-leg on the Left Side of the Abdomen 144

Bidder, G.

Note on Projects for the Improvement of Sponge Fisheries . . . 195

Brebner, G.

Algological Notes 179

ditto 286

Browne, E. T.

On the Changes in the Pelagic Fauna of Plymouth during September, 1893 and 1895 168

BUTLER, G. W. PAGE
Report on the Spawning of the Common Sole in the Aquarium of the Marine Biological Association's Laboratory during April and May, 1895 . 3

CLEVE, P. T.
Microscopic Marine Organisms in the Science of Hydrography . . . 381

CUNNINGHAM, J. T.
North Sea Investigations 10
ditto ditto 97
Additional Evidence on the Influence of Light in producing Pigments on the Lower Side of Flat-Fishes 53
The Reproductive Maturity of the Common Eel 87
Recent Reports of Fishery Authorities—
The Scottish, Newfoundland, and United States Reports . . . 203
Physical and Biological Conditions in the North Sea . . . 233
On the Peculiarities of Plaice from different Fishing Grounds . . . 315

GARSTANG, W.
On *Doris maculata*, a new species of Nudibranchiate Mollusk found at Plymouth 167
Contributions to Marine Bionomics—
I. The Habits and Respiratory Mechanism of *Corystes cassivelaunus* 223
II. The Functions of Antero-Lateral Denticulations of the Carapace in Sand-burrowing Crabs 396
III. The Systematic Features, Habits, and Respiratory Phenomena of *Portumnus nasutus* (Latreille) 402

GÜNTHER, R. T.
The Oyster Culture of the Ancient Romans, *with Plate I.* . . . 360

HODGSON, T. V.
Notes on the Pelagic Fauna at Plymouth, August–December, 1895 . . 173

HOLT, E. W. L.
An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish. Revision of Tables 410

LANKESTER, E. R.
Obituary Notice of the Right Hon. T. H. Huxley . . . 1

NUTTING, C. C.
Notes on Plymouth Hydroids 146

SCHIEMENZ, Dr. PAULUS.
How do Starfishes open Oysters? Translated from the German by E. J. Allen 266

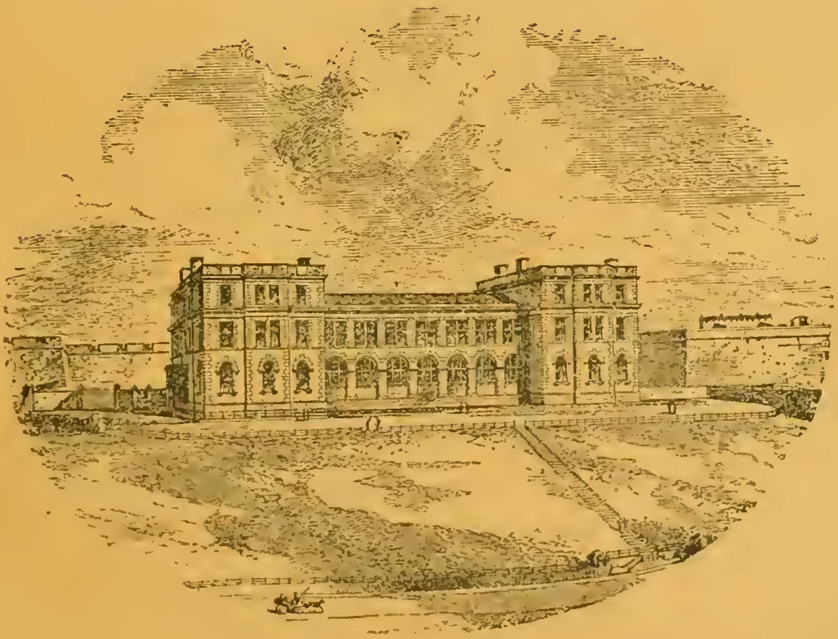
STEAD, F. B.
Preliminary Note on Trawling Experiments in certain Bays on the South Coast of Devon 90
Fourth Report of the Danish Biological Station 213
Note on a Specimen of *Echinorhinus spinosus* 264
Variations and Relationships of the Flounder and the Plaice . . 293

NOTES AND MEMORANDA 73
BALANCE-SHEET FOR 1894–95 86
ditto 1895–96 307
STEAMBOAT FUND. LIST OF SUBSCRIPTIONS 418
INDEX 419

New Series.—Vol. IV., No. 1—issued September, 1895.] [Price 3s. 6d.

Oct. 2, 1895
11,974.

Journal
OF THE
MARINE BIOLOGICAL ASSOCIATION
OF
THE UNITED KINGDOM.



THE PLYMOUTH LABORATORY.

A

PLYMOUTH:
PRINTED FOR THE MARINE BIOLOGICAL ASSOCIATION BY W. BRENDON & SON,
AND
PUBLISHED BY THE ASSOCIATION AT ITS OFFICES ON THE CITADEL HILL.
SENT FREE BY POST TO ALL MEMBERS OF THE MARINE BIOLOGICAL ASSOCIATION:
ANNUAL SUBSCRIPTION FOR MEMBERSHIP, ONE GUINEA.
Agents in London:—Messrs. Dulau & Co., 37, Soho Square, W.

PATRON.

H.R.H. THE PRINCE OF WALES, K.G., F.R.S.

OFFICERS AND COUNCIL.

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G., K.T., F.R.S.
The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Revelstoke.
The Right Hon. Lord Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Sir John Lubbock, Bart., M.P., F.R.S.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Sir Wm. Flower, K.C.B., F.R.S.
A. C. L. Günther, Esq., F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson.
Admiral Wharton, R.N., F.R.S.

COUNCIL.

Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffrey Bell, F.Z.S.
G. C. Bourne, Esq., F.L.S.
Sir John Evans, K.C.B., Treas. R.S.
G. Herbert Fowler, Esq.
S. F. Harmer, Esq.
Prof. W. A. Herdman, F.R.S.
Prof. S. J. Hickson, F.R.S.
J. J. Lister, Esq.
Prof. W. C. McIntosh, F.R.S.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
D. H. Scott, Esq., F.R.S.
Prof. Charles Stewart, V.P.L.S.
Prof. W. F. R. Weldon, F.R.S.

Governors.

Robert Bayly, Esq.

The Prime Warden of the Fishmongers' Company

E. L. Beckwith, Esq. (Fishmongers' Company)

Prof. Burdon Sanderson, F.R.S. (Oxford University).

Prof. Michael Foster, F.R.S. (Cambridge University).

Sir Wm. Flower, K.C.B., F.R.S. (Brit. Assoc. for Advancement of Science).

Hon. Treasurer.

E. L. Beckwith, Esq., The Knoll, Eastbourne.

Hon. Secretary.

E. J. Allen, Esq., The Laboratory, Citadel Hill, Plymouth.

PERMANENT STAFF.

Director.—E. J. Allen, Esq., B.Sc.

Naturalists.

J. T. Cunningham, Esq., M.A.
F. B. Stead, Esq., B.A.

Assistant to the Director.—T. V. Hodgson, Esq.

Oct. 2, 1895

The Right Hon. Thomas Henry Huxley.

THE Journal of our Association cannot be allowed to appear without a few words in memory of our first President, the great naturalist and leader of Science, whom we all mourn.

Huxley's studies in marine biology, and his position as a Government official, as well as his keen, practical common-sense, made his selection as a member of two Government Commissions on Fisheries (in 1863 and again in 1883) very appropriate. He did valuable work on those Commissions, and in 1881 was appointed, by Sir William Harcourt, to be Inspector of Salmon Fisheries. In 1883 he took an active part in the work of the International Fisheries Exhibition, and emphasized in an address given there, the fact that, whilst civilized man had brought all the resources of science to bear on the "harvest of the land," little or nothing had been done in the same spirit for the "harvest of the sea."

When, in 1884, the movement was set on foot for the foundation of the Marine Biological Association, Huxley, as President of the Royal Society, took the chair at the important meeting in the rooms of that Society, at which the Association was founded, and subsequently he consented to be the first President of the Association. With that thoroughness and conscientiousness which marked all his work, our President, though no longer in full health and vigour, attended regularly the meetings of the Council, and gave the most careful attention to the very onerous business which had to be discharged in the early days of the organization of the Association, and the building of the Plymouth Laboratory. His advice and direction were always valued in the highest degree by the Council, and his genial presence at our meetings was greatly appreciated, especially in view of the fact that he travelled from Eastbourne to London, in order to assist us. After seven years, when the laboratory was in full working order, he asked us, on the ground of his delicate health, to accept his resignation of the presidency, which, reluctantly, we did.

The successful launching of our Association, the assistance given to it by the Government, by the City Companies, and by other public bodies, are mainly due to the one fact, that we had at our head a man so profoundly trusted as was Professor Huxley.

The brief description of the purpose of the Association, adopted and circulated by its authority, was due to him, and runs as follows: "To establish and maintain Laboratories on the coast of the United Kingdom, where accurate researches may be carried on, leading to the improvement of Zoological and Botanical Science, and to an increase of our knowledge as regards the food, life-conditions, and habits, of British food-fishes and molluscs."

This is not the place to speak of the manifold labours of our late President in other fields. Our Association is but one of a hundred useful works in which his hand can be traced. But it is, above all, as the man who, without sacrificing the respect of his opponents, has gained for scientific thought a freedom and a hearing, such as were absolutely denied to it in his younger days, that Englishmen must ever remember Huxley with gratitude. Whenever we consult his writings, whether in the laboratory, or in the study—we recognise his power, his extraordinary range and accuracy of knowledge, and his charming style: but we must not think of him either as merely a zoologist, or, as merely an essayist, but as a man who most strenuously, and successfully, fought for the supremacy of Science.

E. Ray Lankester.

July, 1895.

Report on the Spawning of the Common Sole (*Solea vulgaris*) in the Aquarium of the Marine Biological Association's Laboratory at Plymouth, during April and May, 1895,

With preliminary remarks on some of the morphological conclusions that may be drawn from the study of the early embryological history of this form.

By

Gerard W. Butler, B.A.

I. INTRODUCTORY.

FROM April 3rd to May 17th of this year I occupied a table at the Plymouth Laboratory, to study the embryology of Teleosteans. As some of the fish in the flat-fish tank were known to be spawning, a net was fitted to the overflow channel into the adjoining tank. By the kind permission of the Director I examined this net daily, and, as a rule, a number of times a day, so that I obtained a pretty complete record of the spawning of the fish in this tank during the period mentioned.

Four or more species spawned during this period,* but the point most worthy of record is the breeding for the first time in the Plymouth Aquarium, and perhaps for the first time in captivity, of the common sole.

---

* Fertilized eggs of the Plaice (*Pl. platessa*) 2 mm. in diameter were obtained on April 2nd, 4th, 7th, 12th, and some of these hatched out in 10–12 days. Eggs about 1·5 mm. in diameter, apparently those of the "Merrysole" (*Pl. microcephalus*) were obtained unfertilized on April 19th, and fertilized on the nights of May 5th, 8th, and 10th. Some of these hatched out on the 5th day, the water temperature being 13° C. Smaller eggs, also without oil globule, varying in diameter from ·98 mm. to 1·15 mm., and thus answering to the unfertilized eggs of the flounder obtained from different fish, but possibly including eggs of some other flat-fish besides *Pl. flesus*, were obtained repeatedly during April and first half of May, but only one or two fertilized eggs were seen. Attempts to artificially fertilize flounder eggs resulted in nothing beyond the irregular segmentation of some of the eggs. Probably this was due to the only male available not being in proper condition.

II. Dates and Times of Spawning of the Sole.

I obtained unfertilized eggs of the sole on April 3rd and 7th, but on April 12th I found fertilized eggs for the first time. Then, again, on April 20th and 21st there were only unfertilized eggs. From this time onward, however, fertilized eggs were found during the rest of my stay at the Laboratory, sometimes on two consecutive days, sometimes with one day's, sometimes with two days' interval; and unfertilized eggs were the exception. Thus fertilized sole eggs were obtained on April 23rd, 25th, 26th, 28th, May 1st, 2nd, 4th, 7th, 8th, 10th. Then on May 11th, 12th, and 13th there were only a few eggs each day, of which the majority were unfertilized, and then again a plentiful batch of fertilized eggs on May 16th.

The time of day at which spawning occurred seemed to get earlier as the weather got warmer. Thus, during the last week of April, the eggs would be in the first segmentation (two blastomere) stage between 6 and 7 p.m., which, according to subsequent observations, would point to their having been spawned about, or rather before, 4 p.m.; but later on the egg-laying would begin about noon. On one occasion, when it began about 11.30 a.m., it was not ended before 2 p.m., which is not so surprising, since, as will be explained later, the eggs seem to be shed one at a time.

III. On the Appearance of the Ovaries during the Spawning Season.

On May 15th, as it seemed desirable that the state of the ovaries under these known conditions should be studied, it was decided to sacrifice one of the females, of which there were a fair number spawning, and preserve the ovaries for histological study.

I first tried whether any ripe eggs were to be obtained from the living fish, but without success; and on opening the dead fish there seemed to be no quite ripe eggs in the cavity of the ovary tube. This, it may be remembered, was a day on which none of the other fish spawned, though they did on the next day. Judging by the number of fish spawning in the tank and the number of eggs spawned, the number of eggs ripening each day must have been small proportionately to the eggs in the ovary, which is not, of course, surprising, if the spawning is destined to be kept up, on the average every other day, for a period of three months or so. The ova were of all sizes. The largest and most transparent ones, presumably those most nearly ripe, were distributed singly among those less ripe over the whole laminar surface of the ovary, and did not seem to be confined specially to one region of the ovary. However, the third quarter or so of each ovary (reckoning from the head end backwards) was dotted over with small bloodspots, answering to Holt's description of the spent sole.* I presume, therefore, that this region of the ovary was that from which, in the first three weeks or month of the spawning season, the majority of the eggs had been derived.

IV. The Act of Spawning.

At the time of spawning the soles came to the very front of the tank close to the glass, so that on a number of occasions I had a good view of the process.

The soles lay about on the bottom apparently indiscriminately, here one by itself, there two, three, or more near together. One of them would from time to time move leisurely to another place, and in passing by or over one of its companions, would evidently take notice of it, as by feeling it with the under side of its head, but this never led to anything of the nature of pairing, such as some have imagined might occur in the case of the sole; for the fish would again move on and continue the spawning process elsewhere, apparently regardless of the exact position of its fellows, and preoccupied with its own share in the operation. Doubtless, however, such recognitions in passing are the outward sign of the instinct whereby the fish assemble at the spawning time, so that eggs and spermatozoa may rise together in the water, and fertilization take place.

In spawning the sole lay on the bottom of the tank, and raising its head, brought it down again with force. This act involved a certain agitation of the hinder regions of the body also, which was perhaps as important as the more conspicuous movement of the fore part in assisting the expulsion of the ova or spermatozoa, but the appearance was as if the fish desired to create a splash of sand by the downward movement of its head. The movement was quite different from that by which soles commonly cover their upper side with sand, and had not that effect.

The eggs appear to be shed one at a time, each as the result of one of the movements just described. It seemed to me that this movement wafted the egg tailwards; at least a fresh egg commonly appeared above the tail of a fish after each of the head splashes described.

I never actually saw the exit of either ova or spermatozoa from a fish, but if the eggs are shed singly in the manner described, and the spermatozoa in correspondingly small numbers, one could, perhaps, hardly expect to; and I think anyone who saw the eggs slowly rising towards the surface from within an inch or two of the ground, and fresh eggs taking their place to the accompaniment of the movements described, would draw the conclusions that I have.

---

* E. W. L. Holt. "North Sea Investigations" (contd.), *Journal of Mar. Biol. Ass. of U. K.*, vol. ii. (N.S.), p. 371.

In considering how it is that the fish come to the front of the tank, and will spawn undisturbed while you are just on the other side of the glass, instead of, as one might have expected, retreating to the farther side, one must remember that the fish now spawning have been five years or so in the aquarium, and that thus they are not only more or less tame generally, but have probably come to consider the window border of the tank floor as their place of assembly *par excellence*; for it is to that side that they are impelled by the common craving of hunger as feeding time approaches, and on that side that they at all sorts of times tend to linger, from that milder motive of curiosity about us strange creatures in the air-tank on the other side of the glass.

V. General Remarks on the Development.

On the three occasions on which I tried, I failed to obtain eggs from the living fish, and thus I never witnessed the process of fertilization so as to time the development from the very beginning, as I should have liked. Perhaps I should have succeeded, had I captured the fish as soon as they began to spawn. However, I obtained eggs one hour before the first formation of the protoplasmic disc at the lower side of the egg, and two and a half hours before the first segmentation.

The rapid streaming of the protoplasm between the large yolk spheres of the lower part of the egg (which spheres became temporarily transformed into cones pointing downwards), to form the disc, was a very interesting sight. What I saw fully bears out the late George Brook's explanation* of Kuppfer's account of the phenomenon in the herring's egg.

Segmentation was repeatedly followed and sketched, such sketches agreeing essentially as to direction of the segmentation furrows with Wilson's figures of the segmentation stages of the sea bass; but I saw no nuclei in the living egg, except in the "parablast" at a much later stage.

The intervals between the segmentations decreased markedly at first, but a limit was soon reached. The rate of development, of course, varies considerably with the temperature of the water, whether one considers particular stages, or the whole time before hatching.

---

* G. Brook, "The Formation of the Germinal Layers in Teleostei," *Trans. Roy. Soc. of Edinburgh*, vol. xxxiii. part i. (for 1885-6), publ. 1887.

As to the latter, a very healthy batch of eggs, spawned on April 28th, hatched out in numbers on the seventh day, while eggs spawned about a week later, and from thence onwards, hatched out on the fifth day, when the temperature of the water was between 13° and 14° *C.* in the daytime. Both these times are considerably quicker than that of eggs studied by Cunningham, when the water was colder.

I found that even the particularly healthy batch of eggs above referred to, in which the mortality all through had been small for teleost eggs, sank to the bottom, as noted by Cunningham, half a day or so before hatching, and less healthy eggs ceased to float a day or two earlier. For this reason it seems to me that the plan of keeping the eggs, which I adopted primarily for my own convenience in studying and preserving different stages at short intervals, would be more suited to these eggs than the usual narrow-mouthed, wide gauze-bottomed hatching jars. The plan I refer to is that of the plain wide-mouthed glass beaker, with a safety siphon; the form of the latter used being not the sand filter bottom, but that with a glass funnel covered with gauze, which I found being used in the laboratory. A small jet of water, if directed so as to strike the glass side of the vessel a little above the surface of the water, and at a small angle to both the glass and the horizon (pointing downwards), seemed sufficient to keep the eggs circulating, since the surface water being made to revolve, any egg on the surface must soon come within reach of the water coming down the side of the glass, and is then driven gently downwards. With this adjustment the eggs, having small buoyancy, tend to collect on the gauze entrance to the exit funnel; but this can, if necessary, be corrected by making a second small jet of water, from a tube carried beneath the surface, gently play across the gauze mouth of the funnel.

The advantages of this type of vessel over the usual hatching jar to the embryologist are obvious, while to the practical fish hatcher it is a consideration that he can easily keep the glass bottom clean and free from dead eggs by the use of a dipping tube, so that when the eggs sink before hatching, they have not to lie on a bed of putrid eggs. Moreover, the apparatus can be at once moved into any light for inspection, and will work with comparatively little water.

VI. PRELIMINARY REMARKS ON CERTAIN MORPHOLOGICAL CONCLUSIONS TO BE DRAWN FROM A STUDY OF THESE EGGS.

I have for some three or four years been one of those who are impressed with the strength of the case for the "Concrescence Theory," and with the lamentable waste of time in futile researches and discussions on such subjects as the morphology of the notochord and the mesoblast, &c., into which some of those have drifted who have failed to avail themselves of this morphological anchor, with all that follows its acceptance; and I have, consequently, been on the *qui vive* for any evidence which might serve to prove the point definitely to its gainsayers, although feeling, personally, that the study of the living Elasmobranch blastoderm for days and weeks, and of the Teleostean egg for hours (supplemented if necessary by sections) gives ocular demonstration of concrescence.

Now the sole egg, I believe, is capable of giving such proof. The curious aggregates of small oil globules, characteristic of the sole egg, are well known, but I am, I believe, the first who has had the good fortune to study the early developmental history under favourable conditions, and thus to recognize that if suitable eggs be selected, and isolated, and carefully sketched with the camera at short intervals, these oil aggregates, which are at first distributed mainly in a zone below the equator, can (*a*) before the formation of the embryonic ring, be used as fixed points, and serve to show, at least within a small angle, the relation of the plane of symmetry of the embryo to the first cleavage planes, and (*b*) after the first formation of the ring, when they become involved in those relative movements of different parts of the egg, which are usually spoken of as epibolic gastrulation and concrescence, (by those who accept the "Concrescence Theory") may be used, so to speak, as floats whereby to follow these movements.

Having noticed this fact, I thought I could not make better use of the splendid material by the kindness of the Director so freely placed at my disposal, than by concentrating my attention chiefly on that early period of developmental history (the first two days or first day and a half, according to whether the eggs are hatched in seven days or five) during which these and other problems of fundamental morphological interest are to be studied.

I hope shortly, when I have supplemented my serial camera-sketches of different stages of the same living eggs, by sections of corresponding stages from my preserved material, to publish something fuller on the above two points, and on other matters, such as the structure of the egg, the morphological relations of the disc, the parablast and the yolk, and gastrulation. For the present, I may state that :—

I.—The plane of symmetry of the embryo does not bear one and the same fixed relation in all eggs to the first segmentation plane. Thus out of eleven eggs I found that in three the plane of symmetry of the embryo coincided with the first segmentation plane, in four with the second segmentation plane, and in four with a plane bisecting the angle between these.

I bring this forward essentially as a *negative* conclusion; as evidence, I mean, that in this form, at least, the axis of symmetry does not always coincide with the first cleavage plane, or always with the second, as some have suggested. When I speak of "coincidence," I, of course, merely mean that the directions of the planes appear to coincide. To be on the safe side, I will only assert that the planes said to coincide were not more than 15° apart, though I believe that in the case of some eggs it is possible to reduce this angle.

II.—The axial part of the embryo is formed by concrescence of the embryonic ring, or lip of gastrula mouth, from in front backwards.

North Sea Investigations.

By

J. T. Cunningham, M.A.

		PAGE
I.	Statistics of Small Fish landed at Grimsby	10
II.	Notes on the General Course of the Fishing	12
III.	Observations on the Natural History of Plaice	15
IV.	On the Relations of the Generative Organs, and of the Sexes, in some Fishes	28
V.	Two Trips to the Eastern Grounds	33

In accordance with instructions from the Council of the Association, I arrived in Cleethorpes on February 4th last, and proceeded to make investigations into the biological questions presented by the fisheries in the North Sea. A large portion of my time was, however, absorbed by the work of preparing a summary of our knowledge of the natural history of marketable marine fishes, for publication in book form, and consequently the observations to be here recorded are not so extensive nor so complete as I should have otherwise been able to make them. It must also be noted that they are confined to a period of only three months—from the beginning of February to the end of April. The work has consisted only of observations in the fish market at Grimsby Docks, and of the examination of fish there procured in the Cleethorpes Hatchery ; I have not been able to make any voyages on fishing boats. I have received from Mr. Holt, my predecessor at this post, all the assistance that information concerning persons and circumstances could afford me, and I have had the valuable services of Mr. Clark, the caretaker of the Hatchery.

I. STATISTICS OF SMALL FISH LANDED AT GRIMSBY.

The statistics to be here recorded are in continuation of those published in preceding numbers of the journal by Mr. Holt. My responsibility for them consists only in the addition of the figures, and the comparisons made. The counting of the boxes in the market has been entirely the work of Mr. Clark, who has continued to follow the method arranged between himself and Mr. Holt. As far as I am able to judge, the results are very reliable.

Plaice.—During the seven months covered by the figures, no Iceland fish have been landed, and I understand that it is uncertain whether any vessels will visit the Iceland grounds this summer.

	Month.	Total boxes.	Large.	Small.
1894.	October	13,300	13,087	213
	November	20,835	20,607	228
	December	13,640	13,637	3
1895.	January	5,764	5,764	0
	February	6,937	6,937	0
	March	9,180	8,083	1,097
	April	11,614	10,931	683

In March, 13 boxes of the small were from the Humber; in April, 25; the rest being from the east side of the North Sea. In April, 200 of the boxes from the eastern grounds were landed by German steam trawlers, and 16 boxes by cargo steamer, leaving only 442 boxes landed by English trawlers. If these figures are compared with those of the corresponding months in 1893-94, as given on p. 170, vol. iii. of this Journal, it will be seen that there is a considerable falling off in the quantity of small plaice landed, and an increase in the quantity of large. Except October, the total of large plaice for every month is larger, and that of small plaice is smaller for every month, without exception. The totals of the seven months taken together are:

In 1893-94, 51,654 boxes of large, 10,042 small.
In 1894-95, 79,046 „ „ „ 2,224 „

I am unable to give a reason for this. In the earlier period there was only one month of the seven, namely, April, in which any of the vessels were fishing at Iceland, but there may have been diversion of fishing power to other regions. Whether the increased supply of large plaice is due to greater abundance of fish, better weather, or more vsseels, is entirely beyond my knowledge. In the statistics of the earlier period, however, there were eighteen days omitted, and this alone may be sufficient to account for the difference in the figures of large plaice, while it makes all the more striking the difference in the quantity of small. An apparent scarcity of small plaice on the eastern grounds will be mentioned below.

Haddock.—The numbers of boxes of small haddock landed monthly are as follows:

1894.	October	9,138
	November	17,134
	December	12,627
1895.	January	3,806
	February	7,077
	March	12,908
	April	15,908

Comparison of these figures with those given by Mr. Holt on p. 174 of vol. iii. shows a very great increase, except in January, for which the total is smaller. There is no indication, so far as I know, that the supply of large haddock has fallen off.

Cod.—The following are the monthly totals of boxes of trawled codling:

1894.	October	2638
	November	3114
	December	1994
1895.	January	867
	February	2222
	March	4329
	April	5411
		20,575

The total for the corresponding months of the previous year was 17,319; but the figures for nineteen days were not obtained, so that the difference does not appear to be really very great.

II. Notes on the General Course of the Fishing.

In the latter half of February, a large number of steam trawlers were fishing in the neighbourhood of Flamborough Head, where the coast is steep, the 20 fathom line being only four or five miles from the coast, and the soundings descending to 35 fathoms. The principal item of the catch on this ground was large cod, which were taken in large numbers in spawning condition. This region is, in fact, a spawning ground for cod, and I am informed by the fishermen that it is worked for cod regularly every year at this season. The proportion of codling was not great; for instance, in one voyage of a steam trawler, lasting nine days, there were 90 score of cod, and only 4 boxes of codling. There were also caught 10 to 12 boxes of large plaice, a few boxes of haddock (about 20), a few turbot, mostly large, about 1 box of soles, 1 or 2 of lemon soles, and a few boxes of whiting.

Other steam trawlers, but not many, were fishing on the Great Fisher Bank, at depths of 35 to 50 fathoms. The chief item in their takes was haddock, some vessels bringing in 200 to 300 boxes of large haddock, and 6 to 27 boxes of small. They also got usually about 8 to 10 boxes of large plaice, 5 or 6 boxes of witches (*Pleuronectes cynoglossus*), a few large turbot, a few halibut, rarely a brill, skate, roker, cat-fishes, and "monks" (*Lophius piscatorius*).

Some of the smaller steam trawlers, and some sailing smacks, were fishing the Great Silver Pit, on the south edge of the Dogger Bank, and here, as usual in cold winters, considerable numbers of soles were taken, 10 boxes down to 2 or 3 being the usual quantity. Usually I only saw 2½ or 3 boxes of soles landed by a sailing smack, and 5 to 7 by a steamer; but once I saw 10 boxes from a single smack. On this ground haddocks were taken in moderate numbers, also a few boxes of plaice, whiting, dabs, some cod and codling, and ling; turbot were rather plentiful, brill less so.

Others of the smaller steamers fished within a radius of 50 miles from Spurn Head to the east and south-east. These brought in mixed catches—sometimes a number of turbot and brill, a few soles, haddock, plaice, cod, roker, and skate. These grounds appear to be fished more or less regularly all the year round.

The first voyage of small plaice from the Eastern Grounds was landed on March 20th. There were 246 boxes of the small, 29 somewhat larger, and also 4 brill and 1 turbot; but no other fish. They were taken on the Sylt Ground, at 13 to 17 fathoms, south of the Outer Horn Reef Lightship. These fish fetched 11s. to 12s. per box, the larger 18s., while on March 15th the ordinary large plaice sold for 34s. 6d. per box. Another voyage of 230 boxes was landed on March 21st, also from the Sylt rough ground, and another on March 25th, consisting of 150 boxes, from the same neighbourhood. In this last voyage there was a box of small turbot, containing 90 to 100 fish, mostly about 1 foot in length.

In the latter part of March, many steam trawlers were fishing the grounds south of the Dogger Bank, namely, Well Bank, and a place called Markham's Hole, which is 80 miles east of Spurn Head. These grounds are on the south side of the valley called the Silver Pit, and are from 15 to 20 fathoms deep; but the Hole, so far as I can judge, is one of the depressions which descend to 40 fathoms. The catches were mixed, consisting of about 50 to 70 boxes of haddock, about 70 cod, a few boxes of plaice, some soles, lemon soles, and whiting, and a few brill and turbot.

In April, although occasional catches were brought in from the Flamborough Head ground, and from the Great Fisher Bank, a number of vessels were fishing on the Dogger, where, so far as I could learn, fish were very scarce in the winter months. Here, as well as on neighbouring grounds, small plaice were in excess of the large, and formed a few separate boxes; the condition of these small plaice is discussed below. Haddock and plaice formed the main part of the catch. It has been explained in Mr. Holt's papers that haddock are packed for sale on the pontoon in three sizes—the largest, called gibbers, from the mode in which they are gutted; the medium, called kit, because conveyed in kits to the curing houses; and the small. From the Dogger Bank, a week's voyage produced about 30 to 40 boxes of the gibbers, about 60 upwards of kit, and 30 to 50 small. The largest catch I saw from a steam trawler was landed on April 25th, from one week's fishing, and consisted of 6 boxes plaice, 150 boxes kit, 80 boxes gibbers, 3½ boxes small haddock, 1 score of turbot, and ½ score cod. This catch realised £130, which is considerably more than the average value of a week's catch.

I have already mentioned three voyages of small plaice, landed March 20th, 21st, and 25th. The small number landed altogether in March and April offers a remarkable contrast to the condition of things in the same months in 1894. On March 26th there was landed a voyage of 260 boxes, the result of three weeks' fishing south of the Horn Reef. On the 27th another voyage, this time of a fortnight's fishing, of 200 boxes was landed. It should be mentioned here that more than one vessel had tried the Sylt grounds for small plaice before March 20th, and had failed to catch any. The explanation offered to me by Mr. Alward, and also by several of the skippers of steam trawlers, was that the weather had been too cold; that the small plaice bury themselves in the sand in cold weather, and remain motionless, taking no food—hibernate, in fact—so that the trawl passes over them without disturbing them. It is certain that the small plaice in the tanks at the Cleethorpes Aquarium did behave in this manner, and emerged in a lively and hungry condition in the fine warm weather, at the very time that the small plaice were landed at the docks. On the 29th a sailing trawler landed 78 boxes. Voyages of small were landed on April 3rd, 4th, 8th, and 9th, but from this date until the 26th no catches were landed from the Eastern Grounds. It is true that cold easterly winds set in during the greater part of this time, and the weather was dull, and this change in the weather may have been the principal cause of the disappearance of the fish from the market. On the 26th, 30 boxes were landed by a German steam trawler; and on the 29th, 170 boxes from another German boat.

It seems to be the fact that on April 24th, large numbers of small plaice, from the Eastern Grounds, were landed by steam cutters at

Billingsgate. A statement to that effect was made at the conference of the Protection Association, and I saw a considerable proportion of plaice, from 5¼ inches upwards, among those landed at Billingsgate Market on May 3rd and 4th. But I am unable to say whether any were landed in London or other ports between the 9th and 24th, when they were absent at Grimsby.

III. Observations on the Natural History of Plaice.

In order to obtain a more exact and detailed knowledge of the habits and history of the fish on the North Sea fishing grounds, I have, as far as time and opportunity allowed, endeavoured to ascertain the condition with respect to feeding and breeding of the fish that were brought in from different grounds at successive times. The observations I have here to record are merely tentative and preliminary, but I think they are enough to show that the method is a necessary continuation and extension of those of a more general character which have already been applied with good results.

The first sample of plaice which I examined consisted of six specimens caught in the north-west part of the Great Fisher Bank at a depth of 35 to 39 fathoms. They were obtained in the market on February 13th. There were four females 17 in. to 21¾ in. long. Three of these, 21¼ in. to 21¾ in., were approaching the spawning condition: the ovaries were much enlarged, the eggs full of yolk, but no ripe eggs present: they had not commenced to spawn. In the smallest female, 17 in., the roe of the right side was 3$\frac{1}{16}$ in. long, measuring from the anterior end of the ventral fin; the end of it 6¼ in. from the posterior end of that fin. There were no yolked eggs in the ovary. Under the microscope all were transparent, but there were opaque granular masses, which I believe to be evidence that spawning has taken place. I have given in my paper on the "Ovaries of Fishes," in this Journal, vol. ii. p. 154 to 160, some evidence that these masses are the disappearing remnants of partially developed yolked ova, which are always found in the spent ovary. This specimen of 17 in. would undoubtedly have been considered, according to the views hitherto accepted, as immature, but it seems to me it was probably a spent fish. It cannot be asserted as a certainty that these granular masses never occur in an immature ovary; to settle the doubt it will be necessary to make a careful examination of plaice in November and December, when all fish which are about to spawn will have a large amount of yolk in the eggs, and all fish in which the eggs are transparent and yolkless must be immature. In other words, at that season recently-spent fish will not exist, and then it will be possible to ascertain with certainty whether an immature ovary can contain these granular masses. In the meantime it is not certain that this fish, and others like it, are immature, and have not already spawned. The remaining two specimens, 16¼ in. and 17¾ in. long, were ripe males. This length, 16¼ in., was about the smallest of these Fisher Bank plaice, and it follows that these were chiefly mature plaice in the breeding condition. The stomachs of all were empty, or very nearly so; in the intestines of some were a few crushed shells, the remains of previous meals.

On February 16th, I found that most of the fish landed was from the home grounds. There are at Grimsby a number of rather small steam trawlers, which never remain out more than a week, and confine their operations within a limit of about 100 miles from Spurn Light. I noticed that the greater number of the plaice landed were rather small, not forming separate boxes of "small," but each box containing a large number of small at the bottom, with a few large fish on the top. I examined a sample of the smaller. There were seven females, from 11⅝ in. to 14⅝ in. long. One 12½ in. was nearly ripe, a large number of the eggs already transparent, that is to say, almost ready to be shed. All the others had small ovaries, in appearance immature, but in all of them under the microscope the opaque granular masses were very conspicuous. Even the smallest fish, 11⅝ in. long, had the ovary in this condition. It seems probable that all these were spent fish. There were six males, the smallest 10⅞ in. long, the largest 16 in. This last was the only one ripe, in all the others the testis was very thin, and would, I suppose, have been put down by previous observers as immature, but in my opinion were more probably spent. I did not ascertain more particularly where these fish were caught.

On February 27th I saw the fish landed from a steamer which had been fishing off the Leman Shoal, at a depth of 12 to 17 fathoms. She had so many small plaice that they formed 7½ separate boxes, in addition to 35½ boxes of fish of the usual sizes. I bought a whole box of these small plaice, the price of which was 16s. 6d. The box contained 212 fish, the smallest a little over 7 in., the largest between 13 and 14 in. The small plaice from the Eastern Grounds, according to Mr. Holt, were about 300 to a box, the majority from 7 to 13 in. long. It is evident, therefore, that the plaice here considered are within the same limits of size as the eastern small, but apparently a little larger on the average. Examination showed that there were 186 males, and only 26 females. The condition of the males may be thus shown:—

	Ripe or nearly spent.	Apparently immature.
7 in.	1	
8 „	12	
9 „	33	1
10 „	35	2
11 „	60	
12 „	36	
13 „	6	
	183	3

It is obvious that the three in the second column were not likely to be really different from the rest, and I have no doubt that they were really spent.

The condition of the females was:—

	Ripe or certainly spent.	Apparently immature.
9 in.	1	
10 „	1	1 and 1 ?
11 „		4 and 3 ?
12 „	5	3 and 6 ?
13 „		1 ?

The smallest female was $9\frac{1}{8}$ in. long, the right ovary $3\frac{3}{8}$ in. long and flaccid, and this fish had certainly spawned, as there were some ripe eggs still in the cavity of the ovary. Eight of the specimens, 10 to 12 in. long, showed no signs of previous spawning, and were very possibly immature, but the others marked ? showed in abundance, and very distinctly, the opaque granular masses, which I believe to be evidence of previous spawning. One specimen, $11\frac{1}{4}$ in. long, showed very numerous masses of granules: the end of its right ovary was $2\frac{1}{8}$ in. from the anterior end of the ventral fin, and $3\frac{3}{4}$ in. from the posterior end. I consider this fish to have been almost certainly spent. But putting aside all questions of probability, the examination of this sample proves that male plaice are sometimes ripe in the North Sea at 7 in., and females at 9 in. Mr. Holt found a ripe male at 6 in. (see his paper in this Journal vol. ii. p. 376), but regarded it as altogether exceptional, and found only a few nearly ripe at 9 and 10 in., none at 11 and 12. He records one female as mature at 13 in., none at 14, and many from 15 in. upwards. On the other hand, the condition of the sample considered agrees closely with the results I obtained at Plymouth, where I found a male and two females mature at 9 in. Mr. Holt states that he examined the larger fish chiefly during the spawning season, and I can only infer that he did not begin to examine smaller fish until it was too late. The fact that he put down all the females under 13 in. which he examined as immature, tends to support my contention that hitherto plaice which have spawned and recovered, have been frequently confounded with immature. At the same time, it is an established fact that plaice and other fish do not all begin to spawn at the same size, and that some immature specimens are larger than others which are spawning. The question is, what is the maximum size of the immature, and that, in my judgment, cannot be determined until a large number of specimens are examined in November and December.

On March 13th I bought some of the smallest fish out of a box of large plaice from the Great Fisher Bank, in order to further examine the condition of deep-water plaice. Of these, 6 were males from 14⅜ to 17¼ in. long, all ripe. Only 3 were females; one was 12½ in. long, the ovary small and apparently immature, the end of it 2¾ in. from the anterior end, 4 in. from the posterior end of the ventral fin. Only transparent eggs were visible under the microscope, and as far as could be judged at that time of year, the specimen was immature. The second was 16⅝ in. long, and certainly spent, the third 20⅝ in. long, ripe.

On March 20th, I saw landed the first "voyage" of small plaice from the Eastern Grounds. They were caught on the Sylt ground south of the Horn Reef Light, at a depth of 13 to 17 fathoms. There were 246 boxes of small, 29 of somewhat large fish, and the price was 11s. to 12s. a box for the small, 18s. for the larger. I examined a sample of the small: they were taken at random, without any selection, and were given to me by Mr. George Alward. The total number was 55, the sizes and sexes being as follows:—

	Males.	Females.
7 in.	1	...
8 ,,	4	1
9 ,,	4	2
10 ,,	9	6 one spent?
11 ,,	14	12 one spent?
12 ,,	2	...
	34	21

In all the males the testes were a mere thin band, and apparently immature. In none of the females was the spent condition found with certainty, the ovaries were all small, as in the immature, and under the microscope all the ova yolkless. But in nearly all granular masses were present in the germinal tissue, although these in most cases were very rare and small. In one specimen 10⅞ in. long, they were large and numerous, and had obviously the character of dead yolked eggs. In one 11⅝ in. long, no granular masses were seen.

Nearly all these fish were crammed with food only partially digested. In most cases this consisted of Lamellibranch remains, broken shells and flesh. In many of the stomachs there were a number of long white muscular masses 1 to 2 in. long. I identified these as the "feet" of *Solen*, having found them sometimes connected with shells and remains of the entire animal, but many stomachs were full of the muscular masses, with no shells in either stomach or intestine. It appears, therefore, that the plaice bites off the foot of the larger *Solens* without swallowing the whole animal; the entire *Solens* present were small. Less frequently there were present Polychaeta (usually *Nereis* sp.), crabs (*Portunus* sp. of small size), brittle-stars (*Amphiura* sp.), and in one case a Nemertean, apparently *Carinella*. Five of the fish contained nothing recognisable, of the other 50

Lamellibranch	occurred in	42;	84 per cent.
Solen	,,	33;	66 ,,
Polychaeta	,,	17;	34 ,,
Amphiura	,,	5;	10 ,,
Nemertean	,,	1;	2 ,,

On the following day, March 21st, another voyage of small plaice was landed from the same ground, and I bought a sample. I had the smallest selected from four boxes, and the sizes and sexes were found to be as follows:

	Males.	Females.
6 in.	8	12
7 ,,	46	38
8 ,,	53	27
9 ,,	3	
	110	77

I examined the ovaries of two specimens—one 6½ in., one 7¾ in.—and saw no trace of the granular masses. The food was the same as before.

On April 1st a steam trawler landed 10 boxes of large plaice, and 9 of smaller, caught on the western shoal of the Dogger Bank, at a depth of 9 fathoms. I bought a sample of the smaller: there were 19 of them in all. The results of examination were:

	Males.	Females.	
10 in.			1 immature ?
11 ,,	2 spent, 1 immat. ?	...	2 ,, ?
12 ,,	2 ,, 1 ,,	...	2 ,, ?
13 ,,	4 ,,	1 spent	1 ,, ?
14 ,,	2 ,,		
	12	7	

The spent female was 13½ in. long, the ovary 3 $\frac{3}{16}$ and 4 $\frac{1}{16}$ in. from the ends of the ventral fin. Under the microscope it showed no yolked eggs or opaque masses—apparently they had already been absorbed—although the ovary had not lost its collapsed flaccid condition. Nearly all the other females, although otherwise not indicating the spent condition, showed more or less of the opaque granular masses in the substance of the ovary, and I have little doubt that all had spawned. The males also, I have no doubt, had spawned, the testes being somewhat larger and softer than in the immature.

These fish had been feeding, but were not so crammed as those from the Sylt grounds. In 10 the stomach was nearly empty, and the contents of the intestine much digested, though usually containing a few shells. Of the other 9 Lamellibranch remains were present in all, and consisted chiefly of *Solen*. One 13½ in. long had the stomach crammed with bits of white molluscs' flesh about ½ in. long. These were the ends of the siphon tubes of some Lamellibranch, apparently not *Solen*. Polychaete worms occurred in 4.

On April 2nd I examined a few small plaice caught by the shrimp shove-net at Cleethorpes. Among them was a female 7⅛ in. long, the end of the right ovary 1½, 2⅛ in., from the anterior and posterior ends of the ventral fin respectively, the eggs under the microscope without yolk and without any trace of granular masses. Another female was 7 in. long, likewise without any trace of granular masses. These fish were undoubtedly immature. I have found it quite impossible to rely with confidence on the relative length of the ovary, as a criterion to distinguish between the immature and the spent condition. Mr. Holt, in his discussion of the question (vol. ii. p. 368), states that the length of the posterior process of the ovary in the immature condition does not exceed one-third of the distance between the first hæmal spine and the caudal peduncle. This distance appears to be the same as that which I have used as the standard, namely, from the anterior to the posterior end of the ventral fin, but I am in doubt about the point from which the length of the posterior process was measured by Mr. Holt. To obtain a constant point of measurement, I have measured the length of the ovary *in situ*, from the front of the first ray of the ventral fin to the posterior extremity of the ovary. In the immature fish the length of the ovary thus measured is less than the distance from the end of the ovary to the posterior end of the ventral fin, but more than a half of that distance. It is usually very little less than ⅔rds. Now in specimens in which the granular masses are conspicuous, the ovary is often less than ⅔rds of the described distance. I have never seen these granular masses in a plaice less than 9 in. long, so that there is no reason at present to suppose that they ever occur in a specimen which has not spawned. In specimens in which the ovary, measured as I have described, is equal to, or greater than a half of the length of the ventral fin, there is no doubt that the fish is spent. So far, my conclusions agree entirely with Mr. Holt. But that observer has rejected the possibility that the spent ovary might go on diminishing until it was as small as in an immature fish, and he does not mention the granular masses at all. My contention is that not only are the granular masses evidence of previous spawning, but that they are rapidly absorbed, so that in a fish over 9 in. long, there may be, some time after it has spawned, no indication left to distinguish it from an immature fish, which has never spawned at all. I have reason to believe that this complete reversion of the ovary to the apparently immature condition occurs chiefly or only in the smaller, *i.e.*, the younger fish, and does not take place to the same degree in fish which have spawned several times.

On April 15th, I saw thirty boxes of plaice landed from a vessel which had been fishing at Markham's Hole and the Swatchway, grounds to the S.E. of the Dogger Bank, and from twenty to twenty-five fathoms in depth. I bought a sample for examination. There were 23 fish in all—11 females, 12 males.

	Males.	Females.
9 in.	1 ripe	
10 „	2 spent ?	
11 „	4 two spent, two ?	1
12 „	4 one ripe	3 probably spent
13 „	1 spent	4 „ „
14 „		2 „ „
15 „		1 spent.

I could not be quite certain that any of these were really immature. Of the males four were doubtful, two at 10 in., two at 11 in., but I do not believe they were immature. Of the females, the one at 11 in. had no yolk and no granular masses, and may have been immature. Of the three females at 12 in., one showed no masses, the other two showed them very distinctly. Of the four at 13 in., one showed no masses. Of the two at 14 in., both showed the masses. The one at 15 in. showed the masses very distinctly, and was certainly spent. As usual the food was *Solen* and other molluscs, worms, and occasionally a small crustacean.

On May 3rd and 4th, I visited the Billingsgate Market, in London, where I was introduced to Mr. Johnson, the officer of the Fishmongers' Company, and from him received great courtesy and assistance in my enquiries. He informed me that about a third of the supply of fish received there is landed by steam cutters, who bring it from fleets of trawlers fishing in the North Sea, the rest coming by railway. It had been stated a few days before, at a conference of the National Sea Fisheries Protection Association, that great numbers of small plaice were being landed at Billingsgate. On the two mornings when I was there, the proportion of small fish was not so large as it had been, and I failed to obtain a box for complete examination. I saw, however, some of the fish landed from a "cutter," or carrier, and the smallest plaice I could see and measure was 6 in. long. This was one of a few lying about the deck, which had fallen from the boxes. I also examined 8 specimens brought to me by Mr. Johnson, of these only two were over 6 in., the rest were below that size, the smallest being 5¼ in. I could not find out where these fish were caught, except that it was somewhere on the eastern side of the North Sea.

I think it will conduce to clearness and precision in considering the data I have given, to keep separate the questions of size and reproductive maturity. To dispose of the latter first, it seems of interest to me, whether it has a practical bearing or not, to try to discover whether immature plaice are found on all grounds, or to what depths and regions they are chiefly confined. I have described samples, 15 fish altogether, from the Great Fisher Bank, and among them were no immature males, and one female apparently immature. The Fisher Bank is from 20 to 40 fathoms in depth. In the large sample of 212 fish from the Leman ground, there were eight females possibly immature, and three possibly immature males. In 13 fish from the home grounds, I am not sure that any were immature, and the same is true of the 19 from the Dogger Bank. Of the sample from Markham's Hole on April 15th, some may have been immature, but it was difficult to be sure. On the other hand, in the plaice from the Sylt ground, there can be no doubt that a large proportion were immature, all females under 9 in. certainly, and a proportion of those above that size, although I am inclined to think, for the reasons given, that some had spawned. I have not examined many plaice from the Humber, but there can be no doubt that in the earlier months of the year nearly all of these are immature. As far as we can judge at present, it would appear that the year-old fish, all of which are immature, are not taken at the season of the year covered by the present observation, in any considerable numbers on any of the off-shore grounds. I consider that the small plaice from the Sylt grounds and from the Humber, consist largely, but not exclusively, in the case of the former, of year-old fish.

To consider now length only. The lower limit of plaice from the Fisher Bank was 12½ in. Of the small fish from the Leman ground, which is opposite the Lincolnshire and Norfolk coasts, the lower limit was 7 in. for males, 9 in. for females, and only one fish in a box of

212 was under 8 in. Of the sample from the home grounds, there were no males under 10 in., no females under 11 in. Of fish from the Dogger Bank and grounds to the south of it, the lower limit was 9 in. for males and 10 in. for females. In the first sample from the Sylt ground, the minimum was 7 in., and there was only one fish out of 55 under 8 in. In the second sample, selected from 4 boxes, the minimum was 6 in., and there were 104 fish out of 187 under 8 in. At Billingsgate, a considerable number of the plaice landed were under 6 in. The upper limit is also of some importance, although it is not fully determined by these observations. Of the fish from the Sylt ground none were above 13 in. in length; in the sample from the Leman ground the upper limit was 14 in., but there were plenty larger than this in the same catch, and in all the other samples there were fish over 14 in.

It appears, therefore, that in the period covered by these observations, the usual minimum on the off-shore grounds is 9 in. for males, 10 in. for females, but occasionally it may be as low as 7 in. and 9 in. Fish below these limits have been obtained only from the Sylt ground and the Humber. Parts of the Dogger Bank are quite as shallow as the Sylt ground, where the small plaice are taken, yet such fish are not found there. Proximity to the land, therefore, appears to be an essential condition in the rearing of young plaice. But the question is, why are the small plaice so much more abundant on the Continental than on the English side? There can be no doubt that the history of the plaice is the same on the two sides. We have sufficient evidence that the plaice hatched from January to March, are to be found abundantly, in summer, along the edge of the shore on the English side, wherever there is sand or sandy mud. Those of a year old, and some of those which are two years old, are the small plaice which are taken to market by the inshore boats in the Humber, and all along the coast of Lincolnshire, Norfolk, Suffolk, and Essex, and by the large trawlers from the Eastern Grounds. But the difference in numbers obtained on the two sides is enormous. On the eastern side a steam trawler brings in between 200 and 300 boxes after about a fortnight's fishing, but I have not heard of a large trawler ever having been able to get a voyage of small plaice on the English side. The cause of the difference seems to me to lie in the configuration of the sea bottom. There is a rather broad tract, less than 20 fathoms deep, extending from England to Holland, from the latitude of the Humber to that of the north coast of Norfolk. But north of this region the 20 fathom line is about 40 miles from the coast of the islands on the Continental side, from 15 to 3 miles on the English side. South of this region also there is a depression deeper than 20 fathoms, which is nearer to the English side than to the Continental. It may be true that more of the floating eggs and larvæ of plaice are carried to the Continental side than to the English, but this would make no difference, if food for the young plaice, and other suitable conditions, especially shallow water, were not more abundant and more extensive. We have seen that the food of the small plaice largely consists of *Solen*, and it is probable that the abundance of this mollusc depends upon wide tracts of shallow sandy ground in the neighbourhood of the mouths of large rivers. A somewhat similar case is that of Lyme Bay, on the south coast of England, where the 20 fathom line is a long way from the shore, and the smaller Brixham trawlers have been in the habit of taking large numbers of small plaice. In Dr. Fulton's investigations, he took a limit of 12 in., and found that plaice under this size were chiefly confined to depths below 10 fathoms, and a distance from shore less than 3 miles. This was on the east coast of Scotland: the 10 fathom line, according to the chart, is in some places 20 miles from the coast of Sylt Island.

All this, however, being admitted, it does not afford a reason why the young or small plaice should be less plentiful on the English side, off the coasts of Lincolnshire and Norfolk, where the general slope is nearly as gradual as on the Dutch and German coasts. There is another difference to be taken into account in this locality, namely, as a study of the chart will show, the existence of numerous banks and holes and rough rocky ground. The grounds are worked by trawlers, but are intricate, and necessitate short hauls, while the Eastern Grounds are noted for the slight wear and tear which they cause to the trawl, and the long hauls which can be made on them. It appears probable that the number of young plaice reared is proportional, not merely to the area of ground near the coast below 15 or 20 fathoms, but to the area of ground of a certain quality, and producing certain kinds of fish food; and a scientific, accurate comparison of the English grounds with the Continental, from this point of view, would doubtless throw much light on the "eastern question" of the North Sea trawl fishery. I hold strongly to the opinion that the business of naturalists in relation to fishery questions is to establish a sound and extensive basis for conclusions on fishery problems, by a thorough study of the physical and biological conditions of the various fishing grounds. With regard to the North Sea, it cannot be maintained that the investigations already made, valuable as they are, supply anything like an exhaustive knowledge of those conditions. On the contrary, they form merely a foundation and preparation for further progress.

In March, 1894, Prof. Dr. Heincke published in the *Mittheilungen* of the Deutscher Fischereiverein an article on the question of protection of undersized plaice, &c., reviewing at considerable length the report of our Parliamentary Committee on Sea Fisheries, which sat in 1893.

In criticising and objecting to Holt's biological limit of 17 inches for plaice, he maintained that the average size of plaice spawning for the first time is much smaller in the German part of the North Sea than in the English. He stated that as the plaice of the Baltic was, at corresponding stages, a smaller race than the plaice of the North Sea, so the plaice of the eastern side of the North Sea was smaller than that of the northern and western parts. According to Heincke, the existence of local differences made not only the same closed areas and the same close seasons for the whole North Sea, but also the same limit of size, impossible. Heincke mentions no observations which support his assertion, but it appears to rest on his own personal experience, and it will be seen, from the observations above recorded by me, that Mr. Holt's figures were probably somewhat too high. My present conclusion is that although there is considerable variation in the size of plaice spawning for the first time, there is no difference between a German plaice and an English. To those engaged in the fish trade, it may be very beneficial to have a limit of size, to exclude the small plaice, because the uncertainty and risk of the business may be thereby diminished, whether any benefit to the fishery is produced or not. This seems to be especially the case at Billingsgate, although it is, to a certain extent, true in other markets. At the former place, I am informed that a considerable proportion of the smallest plaice are worthless, or very nearly so, and the buyer is unable to judge accurately of the value to himself of the box, as it is sold by auction. The fish at the top of the box are of considerable size, and many a poor dealer, I understand, finds great difficulty in retailing his plaice without a loss. It is certain that numbers of the smallest plaice are thrown away, both at Billingsgate and at the various shops, as worthless, and are carted away for manure. There is practically no demand for plaice 5 or 6 inches long, and dealers naturally object to have to buy the goods they require mixed with a quantity of rubbish which is of no use to them, and often to pay good money for the worthless fish. But all this has little to do with us; we are only concerned with the possibility of maintaining and increasing the natural supply of the larger plaice.

The limit proposed in the bill now before Parliament is 8 inches for plaice. It is clear, from the facts given, that the effect of this, if the law is enforced, will be to exclude the plaice mentioned above —5 to 8 inches in length. But the question is, how far this exclusion will cause the fisherman to avoid certain grounds. It is very doubtful if throwing the fish overboard will lead to their survival, except, perhaps, in the case of small boats fishing in places like the Humber. On the other hand, there is reason to believe that on the Eastern

Grounds the smaller fish are nearer the land, and, to some extent, the existence of a legal limit may have the effect of causing the trawlers to fish further out, where the larger fish are. I hope to study this question by visiting the grounds on the fishing boats. At present, very little of the remuneration is obtained from plaice under 8 inches, so that the effect of the proposed law is not likely to be any very great protection of the small fish. I have always thought that the question of reproductive maturity is not the question of chief practical importance in this matter. To my mind, the question is, can a limit be discovered which will make the small plaice grounds unprofitable, without causing waste on all other grounds. So far as I can see at present, a limit of 10 inches would have conferred considerable protection to the Eastern Grounds, without causing a corresponding or considerable waste on the grounds in the open and central parts of the North Sea.

The probable, or we may say the certain, effects of a limit of 8 inches and of 10 inches can be seen, to some extent, by inspection of the data given in vol. ii., p. 347, of this Journal. The box there recorded from Arlberg, Denmark, containing 198 plaice, would not be affected by the limit of 8 inches, while the box from Schiermonnikoog, containing 286 fish, would lose only 9. With a limit of 10 inches, on the other hand, the latter box would lose 200, and the former would lose 97 out of a total of 193. Of the Humber plaice recorded in the same list, a limit of 8 inches would exclude in one sample 224 out of 425 fish, and a limit of 10 inches would shut out all the 425 except 8.

In the report on the Dutch Fisheries for 1893, Dr. P. P. C. Hoek has published the results of some experimental trawlings made with a hired trawler off the Dutch coast. The trawl used had a beam of 35 feet in length. The mesh of the net was $2\frac{1}{5}$ inches at the cod end, taking the length of the whole mesh, which presumably means $1\frac{1}{10}$ inches from knot to knot. The hauls were made between Terschelling on the north, and the latitude of Amsterdam on the south, and may be considered in three groups—(1) within 6 miles of the coast; (2) 15 to 30 miles off; (3) about 55 miles off. The following are the sizes and number of plaice taken:

First Group of Trawlings.

Sept. 15. Less than 3 miles from shore; depth, 7 to 4 fms. About 175 lbs. of plaice, number not given, size $4\frac{4}{5}$ in. to 16 in.; but of the latter only 1 in 50 fish.

Sept. 14–15. 5 or 6 miles off; depth, 8 fms. About 43 lbs. plaice, $6\frac{4}{5}$ in. to 10 in.

Sept. 15. About same distance; 9 fms. A slightly larger number, $7\frac{1}{5}$ in. to $10\frac{4}{5}$ in.

August 30. Depth, 11 fms. About 26 lbs., $6\frac{2}{5}$ in. to $12\frac{1}{5}$ in.

August 31. Depth, $8\frac{1}{2}$ fms. About 175 lbs., 4 in. to $10\frac{3}{5}$ in.; one in 114 fish was $20\frac{1}{5}$ in.

Sept. 1. Depth, 12 fms. About 96 lbs., $6\frac{1}{5}$ in. to $9\frac{1}{5}$ in.

For the records given a sample only was measured; but in all cases a large proportion were under 8 in., and few over 10 in.

Second Group of Trawlings.

August 24. Depth, 15 to 17 fms. 460 plaice; of 25 measured, 15 8 in. to $8\frac{2}{5}$ in., 10 $8\frac{4}{5}$ in. to $9\frac{1}{5}$ in.

August 28. Depth, 14 fms. 52 lbs., 8 in. to $11\frac{1}{5}$ in.

August 29–30. Depth, 15 fms. 70 lbs., 8 in. to $11\frac{1}{5}$ in., and a few up to $14\frac{3}{5}$ in.

Sept. 5. Depth, 15 fms. $17\frac{1}{2}$ lbs., $6\frac{4}{5}$ in. to $11\frac{2}{5}$ in.

Sept. 5. Depth, 15 fms. 32 lbs., $8\frac{2}{5}$ in. to 14 in.

Sept. 5–6. Depth, 16 fms. 119 lbs., $8\frac{2}{5}$ in. to $11\frac{3}{5}$ in.

Sept. 20–21. Depth, 16 fms. 119 lbs., $5\frac{3}{5}$ in. to $10\frac{3}{5}$ in.

This last haul was about 15 miles from the coast of the island of Terschelling.

Third Group of Trawlings.

Sept. 11–12. Depth, 17 fms. 35 lbs. smaller, $17\frac{1}{2}$ lbs. larger; 8 in. to 14 in., some up to $18\frac{2}{5}$ in.

Sept. 12. Depth, 17 fms. 24 plaice, $7\frac{2}{5}$ in. to $18\frac{1}{5}$ in.

Sept. 12–13. Depth, 17 fms. $52\frac{1}{2}$ lbs., $8\frac{3}{5}$ in. to $14\frac{2}{5}$ in.

The exact proportions below different limits cannot be ascertained, but the above data indicate that a limit of 8 in. would go far to make the ground where the first group were carried out unprofitable. The different sizes on the different grounds are well brought out by the average lengths given.

Thus in the first group the averages were:—

$6\frac{3}{5}$ in, $8\frac{3}{5}$ in., $8\frac{7}{10}$ in., $7\frac{3}{5}$ in., $6\frac{1}{10}$ ins., $7\frac{2}{5}$ ins.

In the second group:—

$8\frac{4}{5}$ in., $9\frac{3}{10}$ in., a little less than 10 in., $9\frac{3}{5}$ in., 10 in., $9\frac{4}{5}$ in.

In the third group:—

$11\frac{3}{5}$ in., 12 in., 12 in.

In Denmark the limit for plaice by law is now 8 in. to the root of the tail, or very nearly 10 in., including the tail. In Belgium the limit enforced is $7\frac{1}{5}$ in. (18 cm.). In France it is $5\frac{3}{5}$ in., while in Holland the only limit is $3\frac{1}{5}$ in. for flounders, and there is no law for plaice.

IV. On the Relations of the Generative Organs and of the Sexes in Some Fishes.

Although a considerable number of observations have been made and published concerning the sizes of ripe, nearly ripe, and spent fish, and on the condition of the reproductive organs in these various stages, we are far from possessing at present a complete and satisfactory knowledge of the changes through which these organs pass in the development of the fish to maturity, and from one spawning period to the next. This is in fact a subject where investigation requires minute microscopic study, and the application of advanced microscopical science; and the investigation is necessarily an extended one, because it involves a complete examination of all stages in a given fish, and a comparison of all the different fishes with one another. I have a few observations and suggestions to offer here in addition to those contained in my papers on the subject in previous numbers of this Journal.

The first point I wish to consider is the remarkable difference in proportional size between the ovaries and testes in different species, and in relation to this, the differences between the sexes in number and size. To Dr. Fulton belongs the credit of having first drawn attention to these phenomena, and he has published some important data concerning them, and suggested some explanations. (See his papers in the 8th, 9th, and 10th Reports of the Scottish Fishery Board). It is well known that in some fishes, as in the herring, the testes or soft roes are as large as the hard, and the same is true of Clupeoids generally. In the cod family it is difficult to judge without accurate weighing, but the testes, which are of a curious frilled shape, quite different from that of the ovaries, do not appear obviously smaller than the latter. In the flat-fishes, on the other hand, the testes are always smaller than the ovaries, and the minimum is reached in the sole, where they are so small as to have been formerly entirely overlooked. Dr. Fulton has given the actual weights of the organs in a number of specimens, but has not worked out the proportion they bear to the weight of the fish. From averages of 10 male herrings and 16 females it was found that in fish of 11·2 in. in length the testes weighed 35·6 grammes, the ovaries 35·0, so that the testes were actually a little heavier. In a male cod 39 in. long the ripe testes weighed 846 grammes, while in a female of 38 in. the ovaries weighed 2,124 gms., or more than twice as much. A difficulty in exact comparison arises from the varying conditions of the organs, whether in the development towards maturity, or whether the discharge of products after spawning has commenced; all that can be done is to compare them just before the commencement of spawning.

In a male plaice 21 in. long the testes weighed 29·5 grms.; in a female 23¾ ins. the ovaries weighed 503 grms. In the lumpsucker, in a male 12 in. long the testes weighed 70·8 grms., in a female 17 in. long the ovaries weighed 878 grms.

If the small size of the testes were compensated by the greater abundance of the males, an approach to equality in the quantity of the generative products might be the result. But the opposite of this, according to Dr. Fulton's researches, is usually the case. Thus in the cod there were found to be 133 females to 100 males, in the plaice 142 females to 100 males, but in the lumpsucker there were only 25 females to 100 males, and in the herring the numbers of the two sexes were very nearly equal. Dr. Fulton considers the probable significance of these relations, and concludes that the testes are usually smaller in fish with pelagic ova, and more nearly equal in those with adhesive ova, and he thinks the explanation is that fertilisation is more certain in the case of pelagic ova, because the sperms move upwards like the eggs, while in the case of attached ova a great deal of the milt is wasted. There is probably much truth in this suggestion, but I would put it in a somewhat different way. In the sea the water is generally moving in one direction or another, and the milt shed into the water disperses by diffusion, even without the movement of a current. Therefore, if the eggs are fixed, much of the milt must travel away from them, and more of it is required. Where the eggs are free in the water like the milt, they scatter together, and are moved together by the currents. It is remarkable, however, that in the angler, of which the eggs, though free in the water, remain connected in a continuous sheet, the males are much more numerous (100 males to 26 females), and the males are also larger, though whether the testes are larger than the ovaries has not been ascertained.

But the proportion in bulk between testes and ovaries differs very greatly among fishes which agree in having pelagic ova. For instance, in the cod the inferiority of the testes is very much less than in the plaice, and in the plaice than in the sole, while in the flounder, although the testes are smaller, the males are more numerous than the females. It seems to me that these differences are to be explained by the differences in the rate of spawning. Some fishes, like the herring, shed the whole crop of eggs for the season at once. The eggs are all in the same stage of development, and therefore are all ripe at one time, and when spawning begins it continues at a rapid rate until the roe is empty, and the fish is spent. Plaice and cod do not spawn so rapidly as this, but it is certain that in both these fishes a large number of eggs can be squeezed from a ripe female at one time, so that the roe is soon emptied. The rate of spawning, and its duration, can be studied by examining the ripe and ripening ovaries, as Dr. Fulton has done to a great extent in his investigation of the fecundity of fishes. In some cases, although the number of ripe eggs present is considerable, there are others in various degrees of development, so that spawning is prolonged. This is the case in the gurnard, and in some fishes with attached ova, such as *Syngnathus acus*, *Anarrhichas lupus* (the cat fish) and others. In the plaice, according to my own experience, and Dr. Fulton's observations, a large number of ripe ova are shed at once, and the season's crop is soon exhausted. There is no prolonged production of young ova to succeed those first shed. The fish being of a high degree of fecundity, and having all its eggs nearly ripe at once, the distension of the body by the ripe ovaries is very great. In accordance with this state of things the testes are rather large, very much larger than in the sole, and spent fish appear early in the spawning season. The spawning process being thus completely and abruptly terminated, the ovary reverts to a resting condition. At Plymouth I found a spent specimen as early as January 28th, at Grimsby the first I recognised was obtained on February 27th. The conclusion that the ovary does revert to its original condition, based on the evidence given in my paper on the ovaries of fishes, vol. iii., p. 154, has been confirmed by my observations this season at Grimsby. It has been shown in former papers by Mr. Holt and myself, that in the spent ovary the chief peculiarity is not the appearance of empty follicles from which ripe eggs have escaped, but the presence of partially yolked eggs, which are found to be afterwards absorbed. But the opaque granular masses to which I have so often referred above, had not attracted my notice very much before the present season. They are easily overlooked, not because there is any difficulty in seeing them, but because they are so indefinite in shape, and do not appear at first to have any important significance. The history of the ovary could be worked out with more certainty if we were able to examine specimens in captivity, the date of whose spawning was known from actual observation. I have in a former paper described a few such specimens, but they were not killed until several months after spawning.

I have not yet made a thorough examination of shotten herring, but the few notes I have made tend to show that in the spent ovary the ova are all quite yolkless and transparent, as in the immature ovary. A newly-spent herring can be recognised from the flaccid and congested condition of the ovary, but it is extremely probable that this condition soon passes away.

The haddock presents a condition similar to that of the plaice, that is to say the spawning of an individual fish is soon over, the development of the eggs being nearly simultaneous. On April 20th I examined

6 specimens in which the condition of the reproductive organs was as follows:—

Length of fish 14¾ in. Testis a thin translucent cord: fish apparently immature.

Length 15 in. Female, ovary small, 1¼ in. long, no yolk, no granular masses: apparently immature.

Length 17¾ in. Female, ovary spent, $1\frac{9}{16}$ in. long, much mucus in cavity. In the germinal tissue yolkless eggs and dead partially yolked eggs as in spent plaice, but the latter were few and scattered.

Length 19¾ in. Female, ovary 2⅛ in., spent. Same condition as in preceding.

Length 20½ in. Female, spent; same condition.

Length 20½ in. Male, spent, testis almost invisible.

There can be little doubt here about the rapid recovery of the ovary, and the danger of confusing immature with recovered fish.

On the other hand, in the lemon dab and common sole, the spawning process in a single female is gradual and prolonged, and spent females do not appear early in the spawning season. When a ripe ovary of these two species is examined, the eggs are not found to be nearly uniform in development, but to form a graduated series down to the minute. In spite of this similarity I have observed that a large number of ripe eggs can be obtained at one time from a lemon dab, and the testes are of considerable size, but still, according to Dr. Fulton's figures, smaller in proportion to the ovaries than in the plaice. The witch appears to resemble the plaice, the eggs developing uniformly, and the testes being rather large.

I have examined a few witches at Cleethorpes. The size of mature and immature specimens has not been so carefully studied in this species as in others. On February 18th I examined 6 specimens. Two were males, both mature, 15½ and 16⅞ in. long; four were females, 16½ to 18⅝ in, and all mature, but not ripe; that is to say, the ovaries were enlarged, and the development of the yolk in the eggs advanced. On February 23rd I examined 4 more, all females, 15 in. to 19½ in. long, and all mature.

Mr. Holt found some lemon dabs immature at 12 in., and 50 per cent. of the females at 11 in. At Plymouth I examined numbers of females down to 7 in. long, and none were immature. My observations were made from January to March, Mr. Holt's between February and September. On February 18th last I examined 6 specimens: 2 were mature males, 12⅛ and 12½ in. long, 3 were mature females, 12½ to 13¾ in.; and one 9¼ in. was an immature female. There could be no doubt about the last specimen, as no spent females were to be found at that date.

In all the fish hitherto mentioned there are no oil globules in the ripe egg, and the development of the yolk follows the course which I have described in my two papers, vol iii. pp. 154 and 258. In all these cases I have satisfied myself that the development of the yolk in the eggs takes less than a year. In other words the formation of the crop of eggs for the next spawning season does not begin until some time, about three or four months, after the preceding spawning. But in my paper, vol. iii. no. 2, I described in the egg of the sole the presence of minute globules in the ova of immature females during the spawning season, and in spent females. Recent observations have shown me that these minute globules occur only in those eggs in which oil globules are present in the ripe condition, and I conclude that the deposit of oily matter commences in the ova long before that of yolk proper.

On April 8th I examined 3 small brill, procured from a lot of 34, brought with 4 small turbots and 120 boxes of small plaice from the Sylt Grounds. One was 9¼ in. long, a male not ripe, but with testes rather large and soft, evidently approaching ripeness. One was 11⅛ in., a ripe male. One was 11½ in., a female, the end of the ovary 4¼ in. from the anterior end, 4⅞ from the posterior end of the ventral fin. All the ova under the microscope were transparent, but except in the very smallest there were small, clear globules, principally collected round the germinal vesicle. I think this specimen could not have matured its eggs during the present spawning season, and would not have been ripe for at least 12 months. On April 22nd I examined another specimen, 15 in. long, in which the left ovary was 3⅞ in. long and 5 in. from the end of the ventral fin. There was nothing to indicate that this specimen was spent, all the ova were transparent, but here and there one showed the scattered globules I have mentioned. This specimen was presumably immature.

On April 24th I examined the ovaries of two turbot. One was 19¾ in. long. The roe was opaque white from the development of yolk, and obviously approaching maturity. Under the microscope the yolk in the eggs was in all stages of development. In some there were only the peculiar globules I have mentioned, in others a little larger, these were more numerous, and began to form a *dark* zone round the germinal vesicle, while in the outer part of the egg were globules of ordinary yolk of a much lighter appearance. In all the eggs in which the development of yolk was considerable, there was an inner darker and an outer lighter zone. The other specimen was 15½ in. long, and the formation of the dark inner zone had commenced in an egg here and there. Apparently this specimen would have spawned this season.

On April 26th I examined a number of *Trigla gurnardus.* I did not note the sizes of these, but all were mature, and in most of them there were some ripe eggs. In each ovary there was every stage of development, from the transparent egg with a few globules to the large also transparent ripe egg, with its large single copper-coloured oil globules. As in the turbot, what may be called the second stage consisted in the formation of a dark inner zone round the germinal vesicle, with scattered globules in the outer region. In the next stage the egg is full of yolk, no clear protoplasm is visible, but there is a marked contrast between the dark inner zone and the light outer. In the fourth stage the contrast is less marked: the dark inner zone appears to consist of very minute globules of oil, and at this stage they run together and form large globules, in consequence of which the inner zone becomes more translucent. In the fifth stage the coalescence of the inner globules and of the outer into larger and larger drops can easily be seen, and it is perfectly obvious that the inner drops form the oil globule of the ripe egg. Thus the oil globule originates in the central part of the egg, and only rises to the surface when the whole yolk becomes a continuous liquid.

These facts considerably modify the criticism I have given in vol. iii. p. 263, of Scharff's account of the development of the egg. I have not his paper here to refer to, but he worked with the eggs of *Trigla gurnardus,* and described the division of the protoplasm of the egg into two layers. In the eggs of plaice and flounder I could only find an outer yolk layer and an inner without yolk. I have now shown that there are at any rate two types in the development of yolk in the eggs, one characterising the eggs without oil globules, the other those that possess the latter. In the ovaries of fish whose eggs possess oil globules, the presence of minute scattered globules, in otherwise protoplasmic eggs, does not imply the "active" condition of the ovary—does not, that is to say, prove that the maturation of the ovary for the next spawning season has commenced. It seems to me quite possible that in these fish also a spent ovary may revert to the condition of the immature, but on this point we have at present little or no evidence. The dark inner zone in the developing eggs above described appears to be due to the presence of exceedingly minute and numerous globules of oily matter, which by their great sub-division and refracting power cause the opacity of that part of the egg.

V. Two Trips to the Eastern Grounds.

In order to acquaint myself, by personal examination, with the condition of the Eastern Grounds, and the products of the trawling there carried on, I have made two trips on board steam trawlers bound to those grounds. On my first voyage, I left Grimsby Docks on May 14th, on board the s.s. *Lucania*, belonging to the Alliance Company. The run was about 260 miles E. ¼ N. When we reached the neighbourhood of the Horn Reef on the 15th, it came on to blow, and we lay-to for twenty-four hours without shooting the trawl. This was the commencement of the disastrous gale, which continued, with little interruption, on the English side of the North Sea, until Monday, May 20th, but on the German, or eastern side, it moderated on Thursday evening, and for the rest of the trip we had very fine weather.

The trawl was first shot on the evening of May 16th, and hauled at 11 p.m., but I did not make any observations until the second haul, at 6 a.m. on the 17th. The position, then, according to the captain, was thirty miles south of the Horn Reef, twenty miles west of the Sylt. The marketable fish taken were haddock, cod, and plaice. Of the last, the smallest was 12¼ in. long. The refuse consisted of whelk spawn and crabs *(Hyas araneus* and *Cancer pagurus).* The bottom was sand and broken shells; there were pieces of shell on the net.

During the third haul the depth was 11 to 13 fathoms, and the bottom consisted of coarse sand, called rice-ground by the captain. A tow net was put on the trawl head, and the tin at the end of it came up half full of this sand, in which were three living specimens of *Amphioxus.* The fish caught were 2 baskets of plaice, none under 12 in., 14 baskets of haddock (9 of kit and 5 of gibbers), 23 cod, 2 turbot 1 brill; none of the turbot or brill under 12 in. The stomachs of the plaice contained *Solen.*

The fourth haul, lasting like the preceding six hours, was concluded at 8 p.m. on the 17th. A net of mosquito-netting on the trawl head, brought up a number of larval flat-fishes in process of transformation, probably plaice and dabs, and also one sand-eel. The fish in the trawl were 14 baskets of haddocks (10 of kit and 4 of gibbers), several cod, 3½ baskets of plaice, the smallest of these being 11½ in. by measurement. There were 2 lemon soles, one of them 8¾ in. long. A large number of dabs were obtained in this and all other hauls, but were not saved for the market, their value, after being iced for some days, not being considered sufficiently great. A few of the largest were cleaned for the cabin table, the rest thrown overboard. The haddocks' stomachs contained brittle stars; these, and all other marketable fish, were gutted before being packed away in the fish hold. Edible crabs occurred in every haul, but were not saved for market, only a few being eaten on board.

At the fifth haul, at 3 a.m. on May 18th, were taken 22 baskets of haddock (7 of gibbers and 15 of kit), and 2 of plaice. A larger number of haddock are usually taken at night than in the day-time.

At the sixth haul, at 10.30 a.m., the catch comprised 8 baskets of haddock, 3 of plaice, 1 turbot, 1 hake, 5 codling, a few whiting, numbers of dabs, and 1 gurnard. The smallest plaice was 10⅝ in. long.

Seventh haul, 5 p.m., May 18th. 9 baskets of haddock, viz., 3 of gibbers, 6 of kit, 2 baskets of plaice. 1 turbot, 28½ in. long, a female, nearly ripe; 1 brill, 13½ in. long, approaching ripeness. The food of the plaice was, as usual, *Solen*.

During the eighth haul the vessel was steered first N.N.E., and then S.S.W., the depth was 13 fathoms and the Inner Horn Reef light was seen, bearing E. by N., distant about ten miles. I could not obtain the exact position for every haul, but it must be understood that trawling was carried on without interruption, so that one or two fixed points are enough to indicate the fishing ground. A steamer carries two trawls, one on each quarter, and as soon as one was hauled, the other was shot. As we were keeping in the same neighbourhood, the vessel was steered on one course for about three hours, and then on the opposite course for the remaining three. It may be pointed out, that the principal part of the catch in these hauls was the haddock. At the eighth—a night haul—there were 8 baskets of gibbed haddock and 20 of kit, and only 2 baskets of plaice.

Ninth haul, 8 a.m., May 19th. The foot-rope was broken and the net torn, an indication of rough ground. The marketable fish were, 8 baskets of gibbers, 16 of kit, 2 of plaice, 4 brill, 2 turbot, about 20 cod, 1 halibut. The kit haddocks measured about 15 in. long, the gibbers 20 to 26 in. The smallest plaice was 12½ in. long, the largest 26 in. Of the brill—2, 13 in. and 14½ in. respectively, were immature females; 2, 14 in. and 16½ in. in length, were ripening. Of the turbot—1, 13½ in., was an immature female; the other, 14 in., a mature male. The smallest cod was 13 in. long, the rest were about 3 ft.—some more, some less. The stomach of one large cod contained 4 sand-eels and 2 crabs *(Inachus)*; another contained 12 sand-eels; another a large crab *(Hyas)*. The halibut was 4 ft. 8 in. long, a spent female, and had 10 haddocks in its stomach.

Tenth haul, 6 p.m.; depth, 13 fathoms. The trawl was down nine hours this time, the day being Sunday. There was in the net 1 mackerel —a ripe male; 3 hake—2 males, 1 female, mature, but not ripe; 7 large turbot, female, mature, but not ripe; 1 brill, over 12 in.; 1 sprat, a ripe female; 4 baskets of kit haddock, ½ basket gibbers; 2 baskets of plaice. In the stomach of one of the turbot were 3 sprats and 2 sand-eels. A few large mackerel were also got at the eleventh haul.

Twelfth haul, 8 a.m., May 20th. During this haul, at 2 a.m., the Outer Horn Reef Light was seen, bearing N.E. by N., and distant about 10 miles. The net brought up 9 baskets of kit haddock, 2 of gibbers, 3 of plaice, 1 of gurnard *(Trigla gurnardus)*, 2 turbot, one 14 in. long, a mature male, one 24 in., a mature female; 25 large cod, and some small. As usual, there were no small plaice, but many large, 20 in. long and upwards.

Thirteenth haul, 5 p.m. The depth of 15 fathoms was obtained by the lead. There were 7 turbot—2 mature females, 29½ in. long, 5 mature males, 14½ to 21½ in.; 2 brill, 17½ in. and 20 in., both mature females. Also 10 baskets of kit haddock, 3 of gibbers, 3 of plaice, and 1 of gurnards. About half a basketful of small haddocks, about 10 in. long, were shovelled overboard with the dabs. The smallest of these were 6½ in. long, but there were few as small as this. The smallest dab was 5 in., an immature female, but nearly all of them were mature and spawning, many being nearly spent.

Sixteenth haul, 4.30 p.m., May 21st. There were 3½ baskets of kit haddock, 1 of gibbers, 3½ of plaice, 1½ of gurnards, a few codling and roker. The plaice were nearly all large, none under 12 in. There was 1 brill, 12¼ in., an immature female; no turbot. 1 *Acanthias vulgaris* and 1 *Echinus* were taken.

At 6.30 p.m. we were steering E. by N., the depth 13 fathoms, bottom fine sand. We saw the Outer Horn Reef Light after dark.

Eighteenth haul, 5 a.m., May 22nd. There were 2 turbot, 25¾ in. and 27½ in., both mature females; 3 brill, 15½ to 18½ in., all mature females; 1 basket of large plaice, none under 12 in., about a basketful of haddock and one of gurnard.

In the last, or nineteenth haul, there were 2 soles, one 7½ in. long, a male, immature, one 11¼ in., a male, mature. A few other soles were taken during the voyage, but never more than 2 or 3 in one haul. Roker, *i.e.*, *Raia clavata*, and other species, were also taken, but I paid no particular attention to them. The most important points noticed in this voyage are the following:—

No small plaice were thrown overboard, because none were taken of so small a size as to be unmarketable. None of those taken were less than 10⅜ in. long, and a large proportion were 20 in. and upwards. The captain said that when we were in sight of the Inner Horn Reef Light, we were on the same ground on which he obtained chiefly small plaice in the previous March. Whatever the significance of that fact may be, supposing it to be correct—and I have no reason to doubt it—it is certain that the small plaice were not there in May.

Only two or three lemon soles and an insignificant number of soles were taken. A few immature turbot and brill were observed, but none were under 12 in. in length.

The only fish thrown overboard were the dabs, a comparatively small number of small haddock, and some small gurnard and whiting.

After my return from this voyage, I noticed in the market that the catches from the Eastern Grounds often included large numbers of small brill and turbot, and a considerable quantity of soles. Thus, on May 30th, a vessel which had been fishing 10 miles off the Sylt Light, at about 13 fathoms, landed about 200 boxes of small plaice, 3 boxes of soles, 130 small brill, and 28 small turbot. By small here, I mean brill and turbot about 12 in. in length, very few of these fish exceeding 14 in. I bought a sample of the brill for examination, not selecting them in any way There were 20 in the sample—3 males, 17 females. The smallest female was 10¾ in., the largest 12¾ in., and all were immature. On examination of the ovarian tissue with the microscope, a few of the eggs, in nearly all the specimens, were found to contain the scattered central globules, which I have mentioned elsewhere, as occurring in immature brill and turbot. The three males were from 10¼ to 11½ in. in length; the smallest was sexually ripe, the other two nearly, but not quite so.

On June 1st I bought a box of small plaice, brought from the ground off the Sylt. The price of this was 3s. 9d. It contained 360 fish—211 males, 149 females. It is of importance to note that the males were the more numerous, although it is known that the females are more numerous in plaice on the whole. The smallest male was 7⅝ in. long, the largest 11½ in. There were 3 males under 8 in., 131 under 10 in. The smallest female was 7⅜ in., the largest 13 in. There were 4 females under 8 in., 86 under 10 in. The total number in the box under 8 in. was 7; the total number under 10 in. 217, or 60 per cent.

I examined the roes of a few of the females microscopically, with the following results:—

Plaice	7¾	in. long.	Ova all yolkless; no opaque masses.
„	8¼	„	„ „ „
„	8½	„	„ „ „
„	8⅞	„	„ „ „
„	8¾	„	A few opaque masses, or dead yolked eggs.
„	9	„	No yolk, no opaque masses.
„	9⅝	„	No yolk, a few distinct granular masses.
„	9⅝	„	„ „ „
„	9⅞	„	„ „ „
„	10	„	Granular masses distinct.
„	11	„	Granular masses distinct, but small.
„	12¼	„	No yolk, no masses.
„	13	„	„ „

On Monday, June 3rd, I examined in the market the fish landed from a steam trawler, which had been fishing about 21 miles off the

Amrum Light, *i.e.*, to the north of Heligoland, and was struck with the very large number of small brill and turbot in her "voyage." I found, by actual count, that she had 646 small brill and 150 small turbot. Many of these brill were under 12 in. and many of the turbot. There were also 26 larger brill, and 10 larger turbot, the largest of the former being 20 in. long, of the latter, 28 in. The rest of the catch included 61 boxes of medium plaice, 100 boxes of small and 7 boxes of soles. The last were by no means undersized. On this same vessel I went to sea the next day, to make observations during her fishing.

We steered E. ½ S. from the Newsand Lightship. The trawl was first shot a little before twelve (midnight), on June 5th. The position was about 18 or 20 miles west of the Sylt; the depth 13 to 14 fathoms.

First haul, 6 a.m., June 6th. The marketable fish were: 5 baskets of kit haddock, 2 baskets of plaice, none small, 4 cod, rather small, 2 coal fish, 6 turbot. Three of the turbot were females, 2 of them 29⅛, 31½ in. ripe, 1, 21½ in., 2 others were mature males 13½ in. to 20 in. The largest turbot yielded ripe eggs freely, and was nearly spent after I had squeezed it: this shows that the turbot, like the plaice, sheds a large number of eggs at once, especially towards the end of the spawning process. The refuse thrown overboard consisted of small haddocks, dabs, gurnards and whiting. There were also half a basketful of common whelks; *Cancer pagurus*, many; whelk spawn, quantities; *Asterias rubens*, many; *Solaster papposus*, many; *Alcyonium digitatum*, quantities.

Second haul, 11.30 a.m. At the beginning of this shot we towed S.E. ½ E., depth 12½ fathoms. Just before hauling we got 11 fathoms. When the fish were on the deck I saw that we were now on the small plaice grounds. The plaice kept for market were sorted by the crew into two classes, according to their size, and the smallest were thrown overboard. I found that the smallest saved was 11 in. long, the smallest in the whole catch was 6½ in. long. After the valuable fish had been picked up the rest were left for me to examine: I found there were about two baskets of plaice, the largest being 10 in. long; all these were shovelled overboard, with a few small haddocks and numbers of small dabs. The fish kept were:—

1½ baskets large or medium plaice.
1½ ,, small plaice.
2 ,, haddock.
½ ,, dabs.
18 pair of soles, none under 8 in.
1 coal fish, 1 *Trigla hirundo*.
5 turbot, 11½ in., 13 in., 14 in., 14 in., 19½ in.
3 brill, 11 in., 13 in., 13 in.

It is evident that the plaice thrown overboard by the captain of this vessel would have been all taken to market by many captains, because I have seen numbers of plaice from 6 to 10 in., in the market at Grimsby.

Third haul, 5.30 p.m. During this shot the vessel was steered first to the S. and we passed near the Amrum Bank, sounding 8 fathoms, coarse sand; then we steered to the W.S.W. As soon as the other trawl was shot, the men began picking out and gutting the fish, shovelling over the worthless fish as they proceeded, to get them out of the way. Some of the small plaice and dabs first thrown over were, therefore, alive: whiting and grey gurnard were also rejected. The fish kept were:—

1 baskets medium plaice.
3½ „ small „
1 „ haddocks.
1 „ cod and dabs.
32 pair of soles.

The smallest plaice kept was 10 in. long: many of those thrown overboard were over 8 in. In reckoning the number of soles, only the larger are counted as pairs, a good many smaller, called slips, not being counted, although taken to market. There were also 28 brill, the largest of which was 17 in. long. I measured and examined these carefully. 21 of them were immature females, the smallest being 11 in. long. Leaving out fractions of an inch, 5 of these were 11 in. long; 9, 12 in.; 5, 13 in.; and 2, 14 in. Two were mature females, 15½ in. and 17 in. respectively. The remaining 5 were males, all immature, though they would probably have become ripe later in the season: 4 of them were 11 in. long, one 12 in. In examining brill and turbot on board ship, I have put down all females as immature which had no yolk in the roe, judging that they would not have spawned this season, while those in which the roes were in process of maturation I have called mature, though many of them had not begun to spawn, and probably had never spawned in their lives when caught. Of these 28 brill then, 9 were under 12 in., and 21 females and 5 males were immature. The turbot were 5 in number, 3 of them immature females, 2 mature males. The females were 11¾, 12¼ and 14 in. long, the males 11¾ and 13 in. long. There were also taken 2 specimens of *Trigla hirundo*, known to the Grimsby fishermen as latchets, to the Plymouth men as tubs; these were large mature fish; and 1 lemon sole 8¾ in. long.

Fourth haul, 11.30 p.m. During this haul the vessel was steered somewhat away from the coast into deeper water, namely, 12 to 13 fathoms. It being dark when the trawl came up, I could not examine the fish very completely. As in other similar cases, I contented myself with making a note of the fish saved according to the information given me by the mate: they were:—

9 baskets of haddocks.
1 „ „ medium plaice.
1 score cod.
11 pair of soles.
1 turbot, 2 small brill.
2 latchets.

Small plaice occurred in insignificant numbers.

Fifth haul, 6. a.m., June 7th. Soon after the trawl was shot, at 12.25 a.m., the Amrum Light was seen just on the horizon, about 20 miles distant. The vessel was steered towards the land, and just before hauling we sounded 10 fathoms, near the edge of the Amrum Bank. The fish of this haul were also not completely examined by me; there were saved:—

3 baskets medium plaice.
5½ „ haddock.
18 pair of soles.
Nearly a basket of turbot and brill, some small.
3 large cod, some latchets.
Very few small plaice.

Sixth haul, 9 a.m. The trawl was hauled up after being down about two hours, in consequence of an accident in putting over the buoy. The captain gave orders to put out the usual buoyed flag-staff to mark this ground, where the fish was fairly plentiful, and when the anchor and line belonging to the apparatus were thrown overboard they were caught by the trawl, and it became necessary to haul.

The largest plaice was 15 in. long, the smallest 8½ in. There were 11 turbot and 15 brill, 3 turbot and 1 brill being under 12 in. Of latchets, 11 were taken; one I opened was a female approaching ripeness, with about 6 sand-eels in the stomach. The latchets were not considered very valuable fish: none were thrown overboard, but a considerable number were eaten on board: the other fish taken for cooking were dabs, whiting, and roker, and occasionally small plaice. The fish thrown overboard from this haul were plaice up to 11 in., dabs up to 11½ in., and also some grey gurnard and whiting. The other fish saved were:—

3 baskets small plaice.
2 „ medium plaice.
1 „ codling and dabs.
½ „ gibbed haddock.
1½ „ kit „

Seventh haul, 2 p.m. The depth where the buoy was put down was 12 fathoms. In this haul there were 4 turbot and 6 brill under 12 in., out of a total of 18 turbot and 24 brill: this is nearly 25 per cent. One brill, about 8 in. long, was thrown overboard dead. There were 18 pair of soles, none under 8 in., few, if any, under 10 in. There were 8 latchets. Of the rejected fish the plaice were 7¼ to 10 in., the haddock about 11½ in., the whiting about 13 in., and a number of grey gurnard were also thrown over the side. There were saved:—

2 baskets of small plaice.
2 „ medium „ 12 to 15 in. long.
2 „ haddock.
½ „ codling and dabs, 1 large cod.

It is difficult to estimate exactly the number, or quantity, of small plaice thrown overboard from this haul, but roughly, there were about 2 basketfuls, besides the dabs, gurnards, small haddock and whiting.

When the trawl came up, I was called to see a small sole, caught in a crevice of the ground rope. It proved to be a *Solea lutea.*

I did not see a sole less than 9 or 10 in. in length all the voyage and believe that, if caught at all, they escape through the meshes. Several of the smaller that are caught are nearly through the meshes when the net is hauled and are dragged through by the men, by hand, as the net comes up.

Eighth haul. Trawl up at 8 p.m., after fishing round the buoy. There were 90 turbot and brill, all rather small, but I only noted 2 turbot and 3 brill under 12 in. Of plaice, the smallest in the haul was 7½ in. long; 2 baskets of the medium size were saved, they were from 12½ to 15½ in. long; also 2 baskets of small, 10 in. to 12½ in. About 3 basketfuls were thrown overboard. There were 30 pairs of soles, the smallest 11½ in. long. As usual, there were some latchets, and 1 *Acanthias vulgaris* was taken. 2 baskets of haddock were saved.

Ninth haul, 2 a.m., June 8th. At the commencement of this haul, the Amrum Light was seen on the horizon, bearing E. by N. and distant about 20 miles; this gives, with sufficient accuracy, the position of the fishing ground. A lantern was attached to the top of the buoyed flagstaff, at dusk, the previous evening. The fish saved were:—

3 baskets medium plaice.
5 „ small.
2 „ gibbed haddock.
4 „ kit „
58 pair soles.
70 turbot and brill.
12 latchets, 2 cod, 10 codling.
½ basket dabs.

Tenth haul, 8 a.m., June 8th. There were very few small plaice this haul and few brill, but turbot and haddock were plentiful; soles were also scarce. The vessel had been further to the westward, although the depth, namely, 10 to 12 fathoms, had not been much greater. I made a careful examination of the turbot. There was one ripe female, 24 in. long and several ripe males. I fertilised the spawn from this specimen and threw it overboard, that it might not be wasted, as the only bottle available already contained fertilised turbot spawn. There were 9 immature females, the smallest 13½ in., the largest 15½ in., and 1 female approaching maturity, 14¾ in. long; 12 mature males, the smallest 13 in., the largest 16 in. long. There were 7 brill, rather small. The rest of the fish saved were:—

2 baskets gibbed haddock.
4½ ,, kit ,,
2 ,, medium plaice
½ ,, small ,, 10½ to 12 in.
11 pair of soles.
14 large latchets, 2 or 3 small.
1 basket of cod.

Eleventh haul, 2.30 p.m., June 8th. This haul we again got more brill, soles and small plaice, and fewer haddock, having steered towards the land again. 3 small plaice, put into a tub of clean water after the men began to gut the fish, lived vigorously for some time, until they were thrown overboard. Many of the small plaice were alive when the first shovelfuls were thrown over. The smallest of them was 6½ in. long and there were numbers 7 in.; one of the latter measured 2½ in. across the broadest part of the body, excluding the fins. The mesh at the cod end of the trawl is nearly 3 in. in length when elongated and it seems strange that plaice of this size do not escape. The reason is that the skeleton is rigid, and the strong anal spine acts as an obstacle; the young plaice, too, has no instinct towards working its way through an aperture as the sole has, and none of the required agility—its only instinctive movement, when disturbed, is to flap its body up and down. The smallest fish in the haul was a dab 4½ in. long, an immature female.

There were 47 turbot and brill—of these, 5 turbot, and 9 brill, were under 12 in. The smallest turbot was 8½ in. long, and its stomach contained 2 sand eels, and 2 small dabs. I examined a sample of the refuse: it contained 27 plaice under 8 in., and 40 over that limit. The rest of the fish saved were:—

4 baskets medium plaice.
6 ,, small ,,
½ ,, gibbed haddock.
1½ ,, kit ,,
½ ,, whiting.
32 pair of soles, the smallest 10½ in.; none thrown overboard.

Twelfth haul, 8.30 p.m., June 8th. At 7.45 p.m. we sighted the island of Heligoland and then turned round and steered north. We lost the buoy, the day having been very foggy, and were unable to find it again. A large specimen of the tope, *Galeus vulgaris*, was caught in this haul; it was a male and measured 3 ft. 8½ in. The fish saved were:—

5 baskets of small plaice.
3 „ medium „
2 „ kit haddock.
1 „ gibbed „
½ „ soles.
24 turbot and brill, rather small.

A quantity of small plaice and dabs thrown over.

Thirteenth haul, 2 a.m., June 9th. At 9.30 p.m., at the commencement of this haul, the Amrum Light was seen, bearing E. by N., and Heligoland Light, bearing S. by W. I was not on deck when the fish were sorted, but some of the smallest were saved for me; they were 6 plaice, 5 in. to 6¼ in. in length; 21 dabs, 2 of them 2¼ in. long, the rest 3¾ in. to 6½ in. The fish kept for market were:—

7 baskets small plaice.
3 „ medium „
1 „ gibbed haddock.
3 „ kit „
50 pair soles.
21 turbot and brill.
1 latchet, 1 cod.

Fourteenth haul, 8.30 a.m., June 9th. We steered in to the eastward, to see if there were more soles to be got nearer the land and at 8 a.m. sounded 9½ fathoms. At this time there were five steam trawlers in sight, one smack, and six German sailing vessels of small size, of a kind called "snibs" by the Grimsby fishermen. There were 60 turbot and brill altogether this haul. I examined 19 brill and 5 turbot. Of the brill, 11 were immature females, the smallest 11¼ in., the largest 13½ in. in length. The other 8 were males, the smallest 10¾ in., the largest 17½ in. long, and all mature except one at 11¼ in., which would probably have become ripe this season. Of the whole 19, 5 were under 12 in.—4 males and 1 female. Of the turbot, 1 at 31¾ in. was a spent female, 1 at 20¾ in. was a mature but not ripe female, 1 at 12¼ in. was an immature female and 2, 12¾ in. and 14 in., were mature males. The rest of the fish kept for market were:—

2½ baskets medium plaice, 12½ in. to 16 in.
5 „ small plaice, 9¼ in. to 12½ in.
1 basket kit haddock.
½ „ gibbed haddock.
½ „ codling and dabs.
3 large cod.
30 pair of soles.

The soles in this and other hauls were ripe and spawning. As usual, a lot of small plaice, gurnard, and dabs were thrown overboard. The soles were more plentiful than was usual for a day haul.

Fifteenth haul, 12.30 p.m., June 9th. Just before this haul we sounded 10½ fathoms. The fish kept were:—

2 baskets of small plaice.
1½ „ medium plaice.
1½ „ haddock.
½ basket of dabs.
½ „ whiting.
20 pair of soles.
34 turbot and brill, many under 12 in.
About 12 latchets.

The smallest brill was 9¼ in. long. The smallest dab saved was 9½ in. long. I was told that the last time the vessel sold her fish the dabs fetched 10s. a box, which is more than the usual price of small plaice. Whiting were saved for the first time this haul, as they do not keep well for many days in the fish-hold.

I examined half a basketful of the stuff thrown overboard. It contained:—

101 male plaice, smallest 6⅛ in., largest 10¼ in.
46 female plaice, smallest 6⅛ in., largest 9¾ in.
18 male dabs, 6½ in. to 9½ in.
17 female dabs, 5¾ in. to 9 in.
7 *Trigla gurnardus.*
Trigla cuculus.
1 *Raia clavata,* 11¼ in. across the pectorals.

Sixteenth haul, 8.30 p.m., June 9th. On this occasion I timed the various stages in the operation of hauling one trawl and shooting the other. The after stopper, which fastens the wire trawl-rope to the quarter of the vessel, to keep it clear of the propeller, was let go at 8.30 p.m. The steam winch was then set in motion and the beam of the trawl was on the rail at 8.40. By 9 o'clock the cod end was hoisted up, the fish emptied out of it and the other trawl shot.

This haul we steered somewhat to the westward, to get away from the small plaice; but the captain said he was afraid we should get away from the soles, too. The catch was not a large one:—

1½ baskets medium plaice.
1 basket small plaice.
1 „ gibbed haddock.
2 baskets kit haddock.
35 turbot and brill.
25 pair of soles.

2 ripe female sprats, 1 hake, and 1 *Acanthias vulgaris* were also taken. About 2 basketfuls of small plaice, dabs, and gurnard thrown over.

Seventeenth haul, 2.30 a.m., June 10th. During this haul we steered again towards the land, with the result of getting more small plaice and more soles, and fewer haddock. The fish saved were:—

4 baskets medium plaice.
11½ „ small plaice.
2 „ haddock.
1 basket codling and dabs.
48 pair of soles.

A few brill and turbot, and a dozen latchets. About 20 basketfuls of small plaice, &c., thrown over.

Eighteenth haul, 8.30 a.m., June 10th. At 8 a.m. Heligoland was plainly visible, bearing S. by W., and about 14 miles distant. The fish saved were:—

4 baskets medium plaice.
7½ „ small plaice.
½ „ gibbed haddock.
2 „ kit haddock.
14 pair of soles, the smallest 9⅞ in.
About 27 turbot and brill.

The smallest plaice was 6¾ in. long. There was a quantity of soft dark-coloured fine sand among the fish.

Nineteenth haul, 2.30 p.m., June 10th. At 1 p.m. Heligoland was bearing S.S.W. The fish were on deck at 2.50 p.m., and at 3.10 many of the small plaice, dabs, &c., were being shovelled overboard, and many were alive. Those shovelled over towards the end of the work of sorting and gutting are nearly all dead. I counted the sexes in a number of the larger or medium-sized plaice, and found 99 females to 43 males, the largest female being 16¾ in., the largest male 16¼ in. The smallest plaice in the haul was 6 in. long. According to the mate's reckoning, there were only 8 pair of soles; I counted 32 soles, the mate neglecting the slips. The small plaice were very abundant, the other fish saved being:—

4½ baskets medium plaice.
13 „ small plaice.
1 basket haddock.
1 „ dabs and codling, 1 large cod.
14 turbot and brill, 1 small turbot being only 9 in. long.

Twentieth haul, 8.30 p.m., June 10th. We steered to the north and somewhat nearer to the land this haul, in order to find more soles: we were out of sight of Heligoland. We sounded 7½ fathoms some time before 6.45 p.m., and at that time 10 fathoms, the ground being sharp gravelly sand. There were a large number of German "snibs" in sight. These vessels are of shallow draft, only partially decked, and smack rigged. They carry small trawls, only about 20 feet long, which they pull up by hand. They must take a large number of the small plaice, but whether they destroy them or not I do not know. Probably they fish principally for the sake of the soles.

This haul produced more soles and fewer plaice than the previous one, which was taken further to the southward:—

1 basket medium plaice.
6 „ small plaice.
33 pairs of soles.
1 turbot 9 in. long, 1 turbot 9¾ in.

Twenty-first haul, 3 a.m., June 11th. As usual in a night haul, soles were taken this time more abundantly: no detailed observations on the fish were made by me. The marketable part of the catch comprised:—

1 basket medium plaice.
5 „ small „
2 „ haddock.
50 pairs of soles.
19 turbot and brill, none large.
3 latchets, a few whiting, dabs, and codling.

Twenty-second haul, 10 a.m., June 11th. This was the last haul: we started at full speed for Grimsby at 10.20.

At 9 a.m. Heligoland was in sight, bearing S. by W. 15 to 18 miles distant and I counted 25 foreign "snibs" in sight.

This haul there were taken 25 turbot, 8 brill. I examined a number of them, namely, 15 turbot and 3 brill. Of the former 12 were mature males, 6 of them 13 in. long; 2, 14 in.; 1, 19 in., and 3, 20 in. Of the 3 females, one 15 in. long was immature, two 22 in. long were mature. Of the brill two were mature males 10 in. and 14½ in. long, the third was an immature female 12 in. long.

The rest of the fish saved were:—

3½ baskets medium plaice.
4 „ small „
3½ „ haddock.
10 soles—4 large, 6 slips.
Some whiting, latchets, and cod.

In one haddock's stomach I found *Trophonia*, whitings, and a dab; in another, brittle stars.

I landed at Grimsby on the afternoon of June 12th and on June 13th examined at Cleethorpes some of the fish I brought from the steamer on which I made the voyage. Among these were 9 soles, of the size at which they are called slips, that is to say, the smallest soles caught. They were $10\frac{1}{4}$ to $11\frac{1}{4}$ in. in length, and all of them were mature males.

I also brought a basket of the refuse from the last haul. It proved to contain :—

105 male plaice, smallest $6\frac{1}{2}$ in., largest $11\frac{1}{2}$ in., next largest 10 in.
71 female plaice, smallest $6\frac{3}{4}$ in., largest $11\frac{1}{8}$ in., next largest 11 in. and $10\frac{1}{2}$ in.
31 male dabs, $5\frac{3}{4}$ in. to $10\frac{1}{4}$ in.
21 female dabs, 5 in. to $10\frac{3}{4}$ in.
6 *Trigla gurnardus*, $9\frac{1}{2}$ to $11\frac{1}{2}$ in.

I examined the ovaries of a few of these fish microscopically:

Plaice 8 in. long, ovary small, ova yolkless, no opaque masses.
„ 8 in. long, „ „ „
„ $8\frac{1}{4}$ in. „ „ „ „
„ $8\frac{3}{4}$ in. „ „ „ „
„ $9\frac{1}{4}$ in. „ ovary small, but opaque masses very distinct and numerous
„ $10\frac{1}{4}$ in. „ one or two dead eggs in ovarian tissue.
„ $10\frac{3}{4}$ in. „ ovary 2 in. from anterior end, 3 $\frac{5}{16}$ in. from posterior end of ventral fin. No opaque masses.

Plaice $10\frac{5}{8}$ in. Opaque masses numerous, small, nearly absorbed.
„ 11 in. Opaque masses and dead yolked eggs very numerous and conspicuous.

Dab $7\frac{5}{8}$ in. Probably spawned, but ovary small and transparent, no opaque masses or yolked eggs.
„ $8\frac{1}{4}$ in. Ovary $1\frac{3}{4}$ in. from anterior end, $2\frac{1}{2}$ in. from posterior end of ventral fin. Almost certainly recently spawned, some partially yolked eggs present, but not dark and opaque as in the plaice.
„ $7\frac{5}{8}$ in. Ovary half as long as the ventral fin, red in colour, contained some half-ripe eggs, but not dead yolked eggs as in the plaice.

I must postpone the discussion of these observations until a future occasion.

Faunistic Notes.

JANUARY TO JUNE, 1895.

By

E. J. Allen, B.Sc.,

Director of the Plymouth Laboratory.

THE following notes on the collecting work carried out during the period from January to June, 1895, follow the lines of Mr. Garstang's notes for 1892 * and 1893.† In putting the observations on record, I should like to thank the various workers at the Laboratory during the period covered, for the help which they have given. My own part of the work has consisted chiefly in keeping the record, and in endeavouring to give a certain amount of continuity to the whole. At the same time the final responsibility for the names adopted must be my own.

What strikes one perhaps most forcibly in keeping a detailed record of collecting operations such as are carried out by the Association, and comparing it with previous records and observations, is the great relative variation in the abundance of different forms from year to year. In any particular year, animals which at a given season are usually quite common, may be almost entirely absent, whilst other forms usually regarded as rare may be taken in great abundance. Several instances of this kind will appear in what follows, and it is from this point of view that such records are likely to be of the utmost value, if continued from year to year. It is only by their means that the modifications of the fauna and flora of any district, due in the first place to the direct action of physical conditions, and in the second to the inter-relations of the various organisms which compose it, may be expected to receive anything like a complete explanation.

---

* This Journal. Vol. ii. N.S. p. 333.

† ,, ,, Vol. iii. N.S. p. 212.

Tubularia indivisa has been unusually abundant, and several colonies with polyps of exceptional size for this locality were taken near the Asia Rock, during the latter half of March. This species was also growing in profusion on the rocks below West Hoe Terrace about the same time. *Tubularia indivisa*, of a more luxurious growth and redder colour than that found in the Sound, was taken on May 8th from beneath the overhanging shelf of rock below the remains of the old lighthouse at the Eddystone. It was growing there in considerable quantity, side by side with a species of *Aglaophenia*, which will be described by Prof. Nutting.

Tubularia larynx, which appears to have been common in the Sound in former years, has not been so during the present season.

Garveia nutans, which has been regarded as a rare form at Plymouth, has been plentiful this spring. It was continually found on the stones dredged in Millbay channel, and on April 8th numerous colonies, covered with gonophores, were growing on the rocks under West Hoe. This species has not, I believe, been previously found at Plymouth between tide marks.

A small species of *Eudendrium*, of very delicate habit, and at once recognisable by the milk-white colour of its polyps, which Prof. Allman is inclined to regard not as *Eudendrium capillare*, which it resembles in some points, but as a new species, was found in large quantities on stones taken from Millbay channel, and bore gonophores during April.

On the 25th and 26th of April, a species of *Syncoryne*, resembling *Syncoryne mirabilis* of Agassiz, bearing medusæ of two kinds, was found by Mr. Garstang at Devil's Point and Garden Battery. This species will be described by Mr. Garstang in detail.

On May 9th another species of *Syncoryne*, resembling *Syncoryne eximia*, but of rather more delicate habit, with the tentacles already formed on the zooids, was found growing on the roots of Laminaria on a buoy moored near the Eddystone.

The interesting hydroid *Corymorpha nutans* has again been obtained. The last recorded instances of its capture at Plymouth is by Mr. Heape,* on May 17th, 1887, in about three fathoms, below Fort Tregantle, in Whitsand Bay. On May 20th of the present year, we succeeded in obtaining three specimens with the dredge, off the same fort, in about nine fathoms, and one mile from shore. One of the specimens had medusæ attached. On the following day, May 18th, our fisherman, Roach, tried with the dredge a patch of sand at the east end of the Breakwater, and succeeded in taking two specimens. From the abundance in which the medusæ of this species occur here during the spring and early summer, it seems probable that the hydroid grows in large numbers somewhere in the neighbourhood, and it is curious that it should be so seldom taken.

---

* This Journal. Vol. i. N.S. p. 394.

Medusæ were very late in appearing this season. During January not a single one was seen, and only one or two Leptomedusæ were taken occasionally in the latter half of February. It was not until the middle of March that they began to be met with in any numbers, when the tow-nets contained a good many specimens of the Anthomedusa, *Amphicodon amphipleurus* of Haeckel (March 15th and onwards), each having numerous medusa buds springing from the base of the tentacle bundle. A few specimens of *Corymorpha nutans* (*Steenstrupia rubra*) also appeared about this time. Leptomedusæ (*Phialidium* sp.) were still found in small numbers, but were not plentiful. Towards the end of March they became numerous.

During April *Amphicodon* generally showed gonads developing on the manubrium, and in May (first seen May 9th) the young hydra form was found inside the umbrella.

At the beginning of April two species of *Tiaropsis*, which will be discussed in detail by Mr. Garstang, were present, and the larger species continued to be taken, the specimens gradually increasing in size, until the end of May. *Sarsia pulchella* and *Margelis* (*Bougainvillia*) *ramosa*, L. Agassiz, both of large size, were fairly common during May. Specimens of *Rathkea octopunctata* were also taken during the same month.

From May 21st onwards, medusæ of the Phialidium group, bearing the parasitic *Halcampa* sp. inside the umbrella, were common.

The first Ephyra was observed on February 19th, but Ephyrae did not become plentiful until the beginning of March.

A month later only Ephyrae of the largest size were taken, and on May 28th the first fairly grown Aurelia (about 3 in. diameter) was seen.

On April 29th a small specimen of *Chrysaora isosceles* (about $\frac{3}{4}$ in. diameter) was taken, and towards the end of May fair-sized specimens of this medusa were common.

The Lucernarian *Depastrum cyathiforme*, which has been taken twice before at Plymouth,* once at Drake's Island and once under Rame Head, has been found on two occasions this year; on February 12th on the shore below Mount Edgcumbe, and on May 15th below Mount Batten.

Bolina hydatina, referred to by Mr. Garstang† as having been noticed during May, 1892, and again in May, 1894, but as being apparently absent during 1893, has been taken this year on several occasions, as before, during the latter half of May.

---

* This Journal. Vol. iii. p. 216.

† This Journal. Vol. iii. p. 216.

Large colonies of *Alcyonium digitatum* have again been growing on the iron piles of the Promenade Pier, a position in which they were found last year.

Post-larval stages of *Arenicola* similar to those described by Dr. Benham * in this Journal, which have previously appeared in February, were not found until nearly a month later than usual, the first recorded being taken on March 25th. A corresponding lateness in the appearance of the regular constituents of the floating fauna, as compared with previous records, has been very marked during the early part of this year.

A specimen of *Sipunculus nudus* about 5 in. long was brought to the Laboratory on April 2nd by a fisherman, having been taken whilst trawling.

On the 5th of the same month, our own man was on board a Plymouth trawler, obtaining fertilised eggs of flat-fishes, when another specimen of about the same size was taken ten miles south of the Eddystone light.

Amongst the Nudibranchiata large specimens of *Aplysia punctata* (5–6 inches long when extended) have been abundant in the Yealm River, and have been spawning freely in the tanks during May and June. *Hero formosa* has been found in considerable numbers six miles south of the Mewstone, and *Triopa claviger*, of which two specimens have been previously recorded at Plymouth,† has again been taken off the Mewstone. Four specimens were found on a mass of the Polyzoan *Lepralia foliacea* on May 28th.

On February 6th Mr. Sumner found on the dredging from Millbay channel two specimens of *Cuthona aurantiaca* (A. and H.), a form which has not previously been taken at Plymouth.

The remarkable scarcity of the common shrimp *(Crangon vulgaris)* in the Sound, during the past six months, is a fact worth putting on record. On spots where one haul of the trawl in an ordinary year could have been relied on to bring up many hundreds of shrimps, we could only obtain a dozen or so at each haul during the early months of the year. This scarcity still exists, though the numbers appear to be increasing. It is difficult to suggest a cause for this immense diminution in the numbers of so common an animal. The shrimp fishermen, I understand, account for the fact by the presence in the Sound during January of large shoals of small whiting, many of which fish, when caught, were gorged with shrimps. My attention was not drawn to the matter until it was too late to make any attempt to confirm the latter statement.

---

* This Journal. Vol. iii. N.S. p. 48.

† Garstang. This Journal. Vol. i. N.S. p. 455.

A fact of a similar nature, has been the almost entire absence from the neighbourhood of the common squid (*Loligo Forbesii*). This animal is largely used by the fishermen as bait, but for the first six months of the year it was impossible to procure even individual specimens, and the fishermen have been put to great straits to get bait of any kind for their work.

Additional Evidence on the Influence of Light in producing Pigments on the Lower Sides of Flat Fishes.

By

J. T. Cunningham, M.A.

I. AN OBSERVATION ON PLAICE AND FLOUNDERS.

IN a communication to the Royal Society (*Phil. Trans.* vol. clxxxiv. 1894, and in this Journal, vol. ii. no. 1), I described a series of experiments in which light was directed upon the lower sides of flat fishes, by means of a tank with a glass bottom, and a mirror placed beneath it. I have now to record an observation which confirms my previous results in a most striking manner. Curiously enough, the effect I am about to describe, in some respects even more important as evidence than those obtained in my experiments, was observed accidentally, or at least incidentally, and was due to conditions which had been quite unintentionally produced.

On December 31st, 1894, I examined all the flat fishes which had been kept in a certain tank, for the purpose of ascertaining their rate of growth. These fishes were five in number, namely:

1 plaice	. 8¼ in. long.	1 flounder	. 6⅞ in. long
1 „	. 7¼ „	1 „	. 8⅝ „
1 sole	. 5¾ in. long.		

There were no other flat fishes in the tank, which was one of the table-tanks in the Laboratory of the Association, at Plymouth. It was 5 ft. long, 2 ft. 6 in. wide and 15 in. deep, and its sides and bottom were of slate, the front of glass. I was surprised to notice that all these flat fishes were partially pigmented on their lower sides. At first this appeared to be a complete nullification of the conclusions drawn from my previous experiments, but further examination of the matter gave it a different interpretation.

In the sole there was very little pigmentation on the lower side, only a little at the base of the tail, and on the lower surface of the tail, but in the plaice and flounders the pigmentation extended continuously over the marginal region of the body and the proximal part of the dorsal and ventral fins. The extent of the pigment in the smaller flounder is shown in Fig. 1. The pigmentation of the outer half of the marginal fins was slight. In the larger flounder the pigmented area on the surface of the body was broader; the central area was unpigmented, with the exception of a narrow patch about the middle of the lateral line, as in the smaller specimen. In the two plaice the pigmentation was not quite so intense and not quite so extensive. In both it was absent, or very nearly so, from the surface of the marginal fins, and from the anterior part of the body, with the exception of a small patch on the bony ridge of the head in the smaller specimen. In both it was present in the regions of the interspinous bones in the posterior three-fourths of the body, both dorsally and ventrally, and also over the whole lower surface of the caudal fin, absent from the central region of the body entirely; there was no patch on the lateral line, as in the flounders.

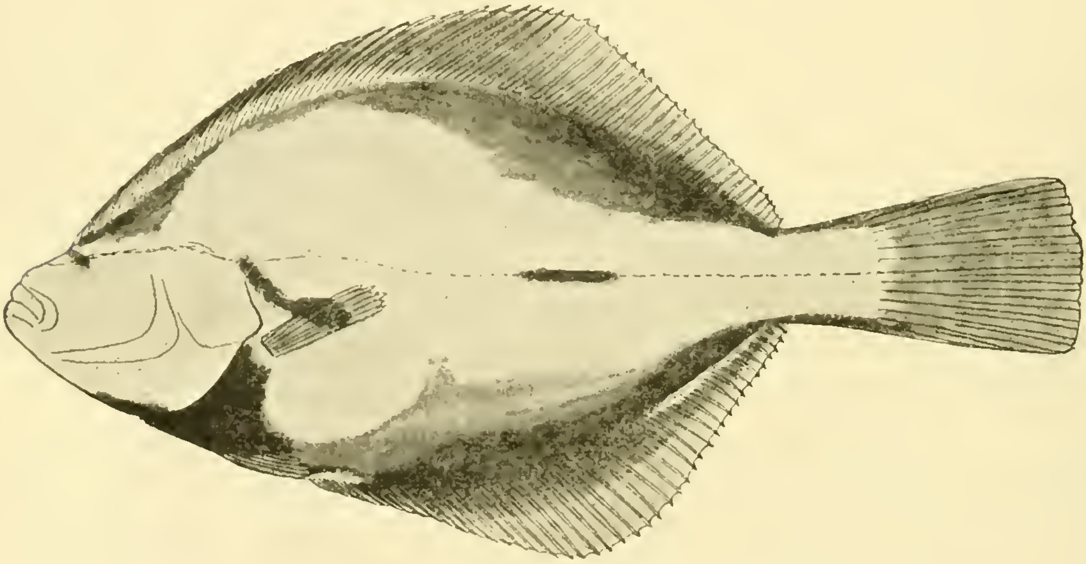


FIG. 1.—Under side of Flounder, showing pigmentation.

It will be clear, therefore, that there was a most remarkable similarity in the distribution of the pigment in these four specimens, which suggests a common cause acting in all of them, and not indefinite "variation." This common cause was access of light to the pigmented areas. There was no sand or gravel at the bottom of the tank, and the fish were resting on the bare slate. The lower surfaces of the fish were not perfectly flat, and therefore certain areas were, when the fish were at rest, in contact with the slate, while other areas were separated from the slate by an interval. The areas of contact were shown by dropping the smaller flounder, in the moist fresh state, on a surface of dry slate, when the areas in contact moistened the slate, while the part of the slate not touched by the fish remained dry.

Fig. 2 is a diagram of the impression thus produced on the slate by the fish, and it will be seen that it is a remarkably exact negative of the distribution of the pigment on the lower surface of the fish. The projection of the area of contact towards the dorsal edge of the fish is not so extensive as the unpigmented area on the dorsal region of the body of the fish, and the tail is in contact with the slate. But in view of the exact correspondence in other respects, these differences are easily explained, and do not invalidate the evidence. The white patch in Fig. 2, corresponding to the area of pigment on the lateral line, and the remarkable correspondence of the area of contact ventrally with the outline of the pigmented area in the fish, as shown in Fig. 2, are sufficiently striking. With regard to the isolated patch of pigment on the lateral line, a difficulty arises. Since this small area is an island surrounded everywhere by surfaces in contact with the bottom, how could light reach it?

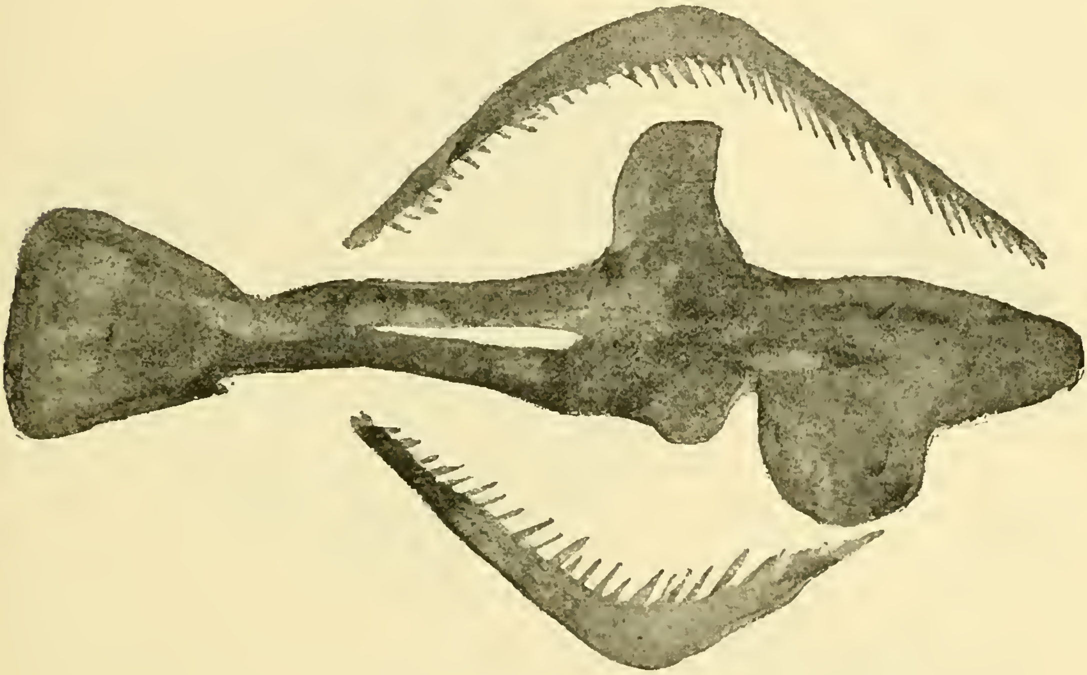


FIG. 2.—Impression of under side of Flounder on dry slate.

In order to prove that light does reach the pigmented areas, I had recourse to photographic action. The same flounder was placed, while still alive, on a sheet of bromide printing-paper in the dark room, and then exposed for a few seconds to daylight, to light coming horizontally. The result of one such experiment is shown in Fig. 3. Here, again, the darkened area of the paper corresponds with remarkable exactness to the pigmented area of the fish, and, most remarkable of all, there is a small darkened patch corresponding to the isolated pigmented patch on the lateral line of the fish. In this particular photographic print the outer region of the bromide paper, beyond the edges of the fish, is lighter than the outer part of the area covered by the fish. This is simply due to the over-exposure of the uncovered area of the paper, causing a partial reversal of the photographic effect. It must be concluded that the rays of light which reach the small depression on the lateral line of the fish pass parallel to the surface of the fish, and therefore do not fall upon it; but when they reach the edges of the depression they are slightly refracted, and so fall upon the surface of the skin in the depression, and give rise to pigmentation. It is possible that this explanation may be corrected by physicists, who know more of the properties of light-rays than I do; but the proof in the photograph that light does reach the depression, and produce an effect there which is absent from the surrounding area, is quite sufficient for my argument.

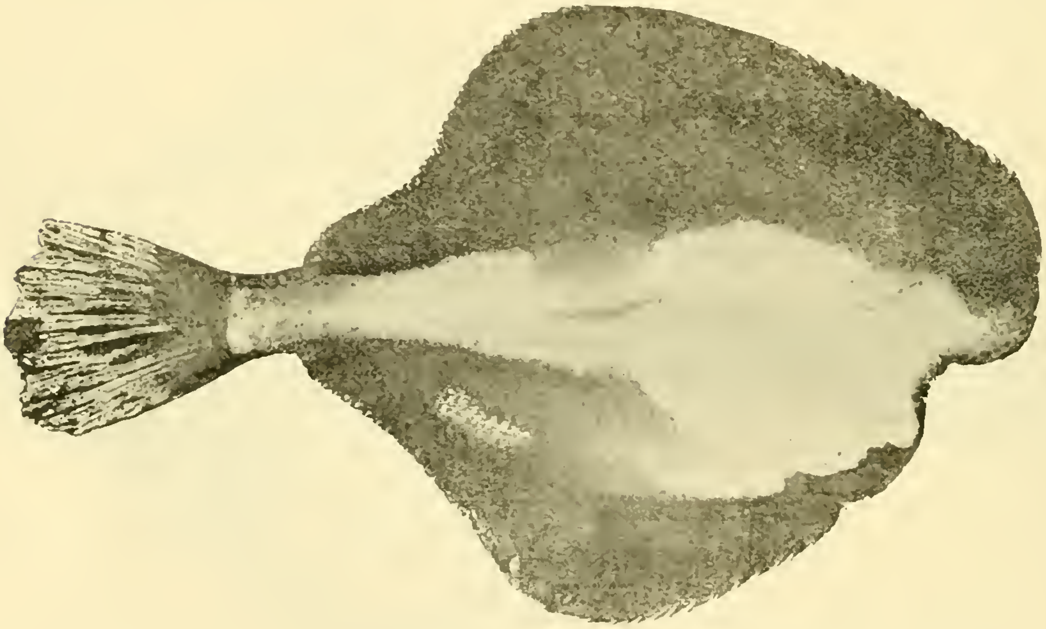


Fig. 3.—Reproduction of impression produced by exposing a sheet of bromide photographic paper, with a Flounder lying upon it, to the action of diffuse light, and subsequently developing.

It will probably be admitted that what applies to one of the fish applies to all. In any case, sufficient examination was made to show that the differences in the amount of pigmentation corresponded to differences in the shape of the lower surfaces of the fish. The lower side of the sole was flat, and in contact everywhere except at the base of the tail. When the fish were alive their caudal fins were usually held slightly elevated above the slate bottom, which accounts for the pigmentation of the lower side of that fin.

It is now necessary to give the history of these fish. (See the previous number of this Journal, vol. iii. p. 273.) They were the survivors of a number put into the tank in the summer of the year 1893, and judged to be hatched in the early part of that year. In April and May were put in five soles, about 1.5 cm. long, and a few flounders from 1.0 to 1.5 cm. long. In June a few young turbot and brill, in the pelagic transformation stages, were put in. In July there were added seven plaice, 6.5 to 8.5 cm. long, and judged to have been hatched the preceding January. On October 19th there were found to be in the tank seven plaice, one sole, three brill, three turbot, and several flounders, but no note was made of the presence or absence of pigment on the lower side. The fish were simply reared in order to see their growth, and it was not supposed that any conditions affecting pigmentation were present. On April 4th, 1894, some of the fish died, and the notes of their condition taken at the time are as follows:

One turbot 10.8 cm. long, a little pigment on the lower side, on the marginal fins, and within their bases.

One brill 11·3 cm. long, pigment on lower side near bases of marginal fins.

One plaice 16·7 cm. long, no pigment on lower side.

One flounder 12 cm. long, some pigment on lower side near bases of fins.

One flounder 11 cm. long, no pigment on lower side.

Thus, in three out of five of these specimens there was some pigment on the lower side in the same region as in the fishes above described from the same tank. But at this time I did not pay much attention to it, and thought it was only an instance of casual variation.

The five fish first described had thus been living in the tank about a year and a half. The tank having a glass front, and being at a height of about 5 feet from the ground, opposite a north window, many of the rays of light entering it must have been nearly horizontal. The glass front, however, did not extend quite to the bottom of the tank, the lower 4 inches of the front being formed of slate. Although it is difficult to make an exact comparison, it certainly seems that the pigmentation was produced more constantly and more rapidly in the unintentional experiment here described, than in those recorded in the previous memoir, which I took so much trouble to arrange. Thus the survivors of the specimens of the brood of 1892, reared in the glass-bottom tank, died on October 20th, 1893, and had therefore been exposed to light very nearly as long as the five described in this paper. They were ten in number, and four of them had no pigment at all on the lower sides. It cannot well be suggested, in explanation of this, that light is not the cause of the pigmentation, but simply the absence of mechanical contact over the parts of the skin which did not touch the bottom in the slate tank. For, in the first place, the same reason would apply to the fish in the glass-bottom tank, where there was no sand, and the marginal parts of the body were equally separated from the bottom; and, in the second place, in the experiments with the glass-bottom tank and mirror, the pigment when developed was most abundant, precisely in those more central regions of the body which were in contact with the glass bottom. I can only suggest at present, that light reflected from rather dark coloured surroundings, is more efficient in producing the pigment than that coming directly from a window and reflected by a silvered mirror. Mr. Poulton has shown how remarkably the colour of lepidopterous pupæ is affected by the colour of the surroundings to which the caterpillars are exposed during pupation.

II. An Experiment on a Piebald Plaice.

In the previous number (p. 271) I described a piebald specimen of the plaice, and suggested the possibility that if the lower side were exposed to light the unpigmented area on the upper side would, *pari passu*, become pigmented. This result was the logical consequence of the hypothesis I put forward in explanation of the fact that, in such specimens, part of the upper side remains unpigmented, while continuously exposed to light in the same way as normal specimens. After writing the contribution to which I refer, I instituted the experiment with the same specimen, not, I must confess, with very sanguine hopes of its success. The specimen had lived in the aquarium from October 3rd to the month of December, without showing any change in pigmentation. I then placed it in a large bell-jar, without any sand, gravel, or other objects in the water, and placed the jar over a mirror in front of a south window. The top and front of the jar were shaded with black paper, so that the upper side received little light, the lower side a great deal. I left the Laboratory on February 2nd, in order to take charge of the east coast work at Grimsby, and Mr. Allen, the new Director of the Laboratory, kindly consented to take this and other experiments of mine under his care. I am most grateful to him for the fidelity with which he executed this trust. When I returned to Plymouth, on June 17th, I found the plaice still alive and in good health. The fish, on examination, was found to be 7 inches long. On the lower side, where previously there was no trace of pigment, there were numerous small patches, scattered principally, but not exclusively, over the peripheral, or interspinous regions. In the area of the upper side, which was previously unpigmented, there were numerous small pigment spots. It is true that the amount of pigmentation thus produced was not great, but it was perfectly distinct and evident, and the duration of the experiment was less than six months. It will easily be seen that this is a most remarkable result—the most remarkable of all that I have obtained in the course of these researches. It is not often in biological investigation that the result of an experiment so exactly corresponds to the prediction, and it affords very strong evidence that the view I advocated of the meaning of the occurrence of unpigmented areas on the upper sides of flat-fishes, approximates closely to the truth. It may be objected that possibly the formation of pigment would have occurred equally if the lower side had not been exposed to light, and it would be desirable to keep other piebald specimens for a length of time under normal conditions. But it can scarcely be maintained that the unpigmented area, when the fish was free, had been shielded from light, and that pigment would have been produced in the aquarium merely in consequence of the exposure of the upper side alone. We have no facts to indicate that the peculiar distribution of pigment in these specimens undergoes changes in the lifetime of the individual, in a state of nature, or in the aquarium, under ordinary conditions. We can only hold, at present, that the pigmentation is constant for the individual, under the usual conditions, although in the face of the result here recorded, it will be advisable to test this assumption. I hope, at some future time, to publish figures shewing the specimen before and after the experiment; but in the mean time have thought it well to place the result on record.

The Reproduction of the Lobster.

By

E. J. Allen, B.Sc.

Director of the Plymouth Laboratory.

The Habits and Development of the Lobster, and their bearing upon its Artificial Propagation. By Francis H. Herrick, Professor of Biology in Adelbert College. *Bulletin of the United States Fish Commission*, vol. xiii. 1893.

The Reproduction of the Lobster. By Francis H. Herrick. *Zoologischer Anzeiger*, xvii. August, 1894, and xviii. June, 1895.

Lobster Reproduction. By S. Garman, Mus. Comp. Zool. Cambridge, Mass. U.S.A. *Zoologischer Anzeiger*, xviii. Feb. 1895.

Der Helgolander Hummer ein Gegenstand deutscher Fischerei, von Dr. Ernst Ehrenbaum. *Wissenschaftliche Meeresuntersuchungen herausgegeben von der Komm. z. wiss. Untersuch d. deutschen Meere in Kiel u.d. Biol. Aust. auf Helgoland*, Neue Folge, heft i. 1894.

Amongst the numerous subjects which have occupied the attention of the fishery authorities of the United States, that of the great decline in the productiveness of the lobster fishing industry has received much consideration, and several competent naturalists have, in consequence, devoted themselves to a scientific study of the habits and life-history of the American species. This species *(Homarus Americanus)* is so nearly allied to the European lobster *(Homarus vulgaris)*, that the results arrived at for it, with regard to such questions as the time of year at which spawning takes place, the length of time during which the eggs are carried by the female attached to the under side of the abdomen, and the time of year at which the eggs are hatched, might be expected to apply, to some extent at least, to the latter. That this is so, appears to be abundantly proved by Dr. Ehrenbaum's study of the lobsters which frequent the shores of Heligoland, and certain observations which I have been able to make on lobsters taken in the neighbourhood of Plymouth during the last two years, in the course of my work on the nervous system of the embryo, also tend to confirm this view.

In America, the investigation of the subject seems to have been carried on independently, at about the same time, by Herrick and

Bumpus, working at the U.S. Fish Commission Station, at Woods Holl, Mass., and by Garman, in connection with the State Fish Commission, of Massachusetts. It would appear that Herrick's work was commenced during the season of 1889, his most important results being published in May, 1891,* whilst Garman turned his attention to the subject in 1890, and reported his conclusions to the Massachusetts State Fish Commission, in December, 1891. On most points of importance, the independent researches of these different investigators are so much in accord, that there can be little doubt as to their correctness.

The time of year during which eggs are laid by the American lobster appears, from Herrick's recent papers † to be less restricted than had previously been supposed. As the result of his earlier work, he was of opinion that the period of egg-laying was confined to the summer months, and that the eggs were carried by the female until the summer following, when they were hatched. A similar view is also taken by Garman. This statement of the facts, however, Herrick now regards as only partially true, for, whilst the greater number of females deposit their eggs during the months of June, July, and August, a considerable number—probably, at least, ten per cent.—lay eggs during the autumn, winter, and spring months.‡

For eggs laid during the summer, Herrick, Bumpus, and Garman agree as to the time occupied in development. They are carried by the female from ten to eleven months before being hatched, this event taking place, in the majority of cases, during June and July of the year following that in which they are laid. During the first few weeks development proceeds rapidly, the eyes being already visible after a month from the time of laying. As the colder weather comes on the process is much retarded, and advance is slow during the winter. According to Herrick, however, the period of fosterage varies considerably in eggs not produced in the summer, some of which may hatch in the fall, and possibly in the winter months.

On these points Ehrenbaum is able to give valuable information concerning the Heligoland lobsters. Special opportunities for the study of the subject are afforded at this place, as the fishermen and dealers keep great numbers of lobsters in large, floating cages for considerable periods, especially in summer. In these cages, however, the females do not, in the majority of cases, deposit their spawn, probably on account of their being shut up in a confined space with a number of their fellows. In cases where the ova are mature, but are not shed, a curious physiological process is set up, the yolk of the unlaid eggs being re-absorbed, and passing into the blood. The blood, in this way, becomes dark green, or almost black, and the dark colour is visible through the thin membranes, especially on the under side of the abdomen. Such animals are known as "black" lobsters, and, if the process has been allowed to proceed far, they are unsaleable. The first appearances of this blackening are, therefore, carefully watched for by the owners of the cages, in order that the animals may be sold before they become valueless. "Black" lobsters begin to appear about the end of July. Ehrenbaum states also, that, in individual cases, lobsters in the cages have spawned, the dates given being 20th, 23rd, and 26th July, the first days of August, and the 28th August. He is also able in two cases to give direct information as to the time the female lobsters carry their eggs. In the first case, eggs spawned during the early days of August, 1892, commenced to hatch on the 20th July, 1893. In the second case, the eggs were laid on the 28th August, 1893, and the majority of the larvæ hatched on the 21st July, 1894. This would give about eleven months as the period of incubation. It should be noted, however, that the lobsters must have been kept in a state of confinement during the time that the eggs were developing.*

---

* *Johns Hopkins Univ. Circulars*, vol. x. no. 87, and *Zool. Anzeiger*, nos. 361 and 362.

† *Zool. Anzeiger*, August, 1894, and June, 1895.

‡ Nielsen states that, in Newfoundland, the larger lobsters spawn from the middle of June till the middle of August, whilst the smaller do not lay until the latter part of October and November. (*Annual Report, Newfoundland Fisheries Commission*, 1889, p. 12.)

My own observations on our English lobster *(Homarus vulgaris)*, although not made systematically for the purpose of determining these points, but, rather, from the necessity of examining numerous egg-bearing females at different times of the year, in connection with other investigations, agree with those of Ehrenbaum in pointing to the conclusion that, on the whole, the history of the reproduction of this species is similar to that of the American representative of the genus.

Females with newly-laid eggs were first obtained during the latter half of July, but out of a large number of lobsters examined, only two specimens in this condition were found. During August and September my work on the subject was interrupted, but on taking it up again in October (1893), females carrying eggs were plentiful, but all the eggs were either in the nauplius stage, with no eye-pigment yet deposited, or in stages in which eye-pigment was just commencing to be seen. These facts, namely, that newly-laid eggs were scarce during the latter half of July, whilst they were numerous, but all were at least in the nauplius stage, in October, would seem to show that August is the month during which most of the females spawn. Development during the winter months took place very slowly.

---

* In the sixth *Annual Report of the Fishery Board for Scotland*, p. 196, Prof. Ewart and Dr. Fulton state that in Rothesay Aquarium, a female, with ova, being placed in the tanks in August, 1886, hatching was only completed in August, 1887, some of the young lobsters being hatched as early as April. It seems fairly certain from this result, that confinement tends to produce an abnormal rate of development, as, in the case of lobsters captured when the eggs are nearly ready to hatch and placed in the tanks of the Plymouth Laboratory, hatching is usually completed within a week, at most, from the time it commences.

The first lobster which I was able to obtain during the following year with eggs on the point of hatching, was brought to the Laboratory on the 20th of March, and larvæ were set free on the 29th of the same month. This lobster, which was stated to have been taken in deep water off the Eddystone, appears, however, to have been quite exceptional, for, in spite of repeated endeavours, no specimen could be again procured with ripe eggs until the middle of May. From this time they became more frequent, the largest number being obtained in June. By the middle of July only occasional specimens were seen, whilst after the end of that month no more could be obtained. During the last fortnight of July the two seasons appeared to overlap, very few lobsters being in berry at all; whilst of those which were, the number having ripe eggs appeared to be about equal to that of those whose eggs were newly spawned.

On the whole, therefore, it is probable that, in this district, the majority of lobsters lay their eggs during August, and the majority of eggs are hatched during June, the period of fosterage being at least ten months.

Coming to the question of the interval which elapses between the hatching of one brood of eggs and the laying of the next, the authors are agreed that this must be at least a year, whilst Ehrenbaum would make it considerably longer. The reasons brought forward by the American naturalists in support of their conclusions on this head are, in the first place, the immature condition of the ovaries of females which have recently hatched their eggs, and the slow rate of maturation of the eggs in the ovary, which render it impossible that the eggs should be ready for laying during the summer in which a brood has hatched; and, secondly, the fact that during the winter months a large proportion of the females captured do not carry eggs.

As already stated, Ehrenbaum makes the interval much longer, and considers that, on the average, a female lobster produces eggs only once in four years. This result is so extraordinary, and if the conclusion can be maintained, is so important, that it is worth while stating in full the evidence on which it is based, and I give, therefore, the following translation of Ehrenbaum's remarks on the subject:

"If eggs were laid every year, then, in consequence of the long duration of the hatching period, females bearing no eggs on the abdomen would seldom occur, which is by no means the case. It can rather be proved with tolerable certainty that the intervals between two consecutive spawnings extend over two, three—or, indeed, more—generally over four years. . . .

"The report by J. C. Ewart, on the Scotch lobster fishery, already referred to (6th Annual Report of the Fishery Board for Scotland, 1888, p. 196), contains the statement that, according to the testimony of the lobster fishermen, about 30 per cent. of all the lobsters caught are females bearing spawn. But as males and females are represented in about equal numbers in the catches—I have found 2,200 males to 2,030 females,* in an enumeration extending over the whole year—according to the statement made above, about 60 per cent. of all the females carry eggs, which would indicate an interval of scarcely two years between two consecutive spawnings.

"The matter was of sufficient interest and importance to justify closer investigation, and I have therefore made statistical observations extending over the whole year, whenever suitable opportunity offered, on the number and percentage of egg-bearing females in the catches. In doing this I have not counted the individual catches, but those collected by the dealers in the lobster cages, and have obtained the following results:—†

Date.	Total Number.		Females with Eggs.		Eggs newly laid.	"Black" Females.	Eggs far developed.	Remarks.
	Males.	Females.	Number.	Per cent.				
1892. July 25th	38	21	—	35·2	—	—	—	All just before or just after moulting.
	15	61	29		2	—	—	
Aug. 13th	86	75	35	46·6	4	7	—	
Sept. 14th	97	91	40	44·0	—	7	—	
Nov. 8th	123	78	23	29·5	—	—	—	Unsorted catches.
Dec. 7th	207	162	31	19·1	—	—	—	,, ,,
,, 10th	94	67	9	13·5	—	—	—	,, ,,
,, 14th	61	102	25	24·7	—	—	—	,, ,,
,, 20th	276	160	27	16·9	—	—	—	,, ,,
1893. Feb. 20th	310	212	49	23·1	—	4	—	,, ,,
May 17th	277	270	46	17·0	—	—	5	,, ,,
June 13th	246	309	64	20·7	—	—	—	Caught since May 17th.
July 13th	111	138	64	46·4	—	—	21	Caught since June 13th.
,, 25th	106	171	45	26·3	2	—	3	Unsorted catches.

"For the better understanding of these figures, the following must be mentioned:—

"The "black" females are reckoned as egg-bearing, since, under natural conditions, *i.e.*, if they had not been confined in the cages, they would have spawned.

---

* Herrick found, however, among about 3,000 animals, a slight excess of females.

† Herrick (*Zool. Anz.* 1891, p. 134) has given a similar table, which, however, does not give the same result.

"As regards the first three entries, which relate to July 25th, August 13th, and September 14th, 1892, it cannot be maintained that the catches still retained sufficiently closely the natural composition which they possessed when first taken. In the summer the dealer sorts his wares, in order to render selection for sale more easy. He divides the small from the large, puts such lobsters as are about to moult in a special part of the cage (it is in this way that the animals enumerated on the 25th July, 1892, are divided), and prefers to sell the females without eggs on the abdomen first, in order to guard against their becoming "black." The latter circumstance is the cause of the percentage of egg-bearing females, in the first three entries on the list, being somewhat higher than in the following. In calculating the mean, however, this is hardly noticeable. The last ten enumerations are all made, on the other hand, on material which had not yet been sorted, and which therefore possessed the original constitution of the catch. Care was also taken that nothing should be counted twice, for each time new cages which had not previously been looked through were examined.

"Reckoning the whole thirteen entries, the mean percentage of egg-bearing females is 25·4 per cent.; the last ten, it is only 23 per cent.

"It will not, therefore, be an error to maintain that never more than the fourth part of the female lobsters capable of reproduction actually carry eggs; or, in other words, that a female lobster, as a rule, actually produces eggs only once in every four years." *

Few will be inclined to object to the author's exclamation, "Das ist eine Thatsache, die allerdings zu denken giebt!" but whether, as a result of the thinking, all will be ready to accept the conclusion arrived at, is another question. At first sight, the argument presented appears to be conclusive, but a little consideration will, I think, lead to the conclusion that at least one other explanation of the facts is possible, for it must be borne in mind that Ehrenbaum was not dealing with the number of lobsters living in the sea, but with the number caught in the traps. It is, to say the least, not improbable that a female bearing eggs would be much more wary of entering a trap than one not so encumbered, especially if the trap already contained other lobsters, including females without eggs. The pugnacious habits of these animals are matters of common experience, and I have, on several occasions, known two of them, confined in one tank, continue their

---

* "A false interpretation of the facts can only be possible in so far that perhaps, sometimes, females may have been counted as 'not egg-bearing,' although they were slightly under 24 c.m. (9½ inches) long, and therefore not yet capable of reproduction. So far as could be judged by the eye, however, the young animals not yet capable of reproduction during the enumeration, were always left on one side."

warfare until one or the other has been killed. The loss of claws and legs is of quite frequent occurrence; and the fisherman, before confining lobsters in a store-pot, invariably cuts the pincer muscles of the big claws, in order to prevent them injuring each other. Even if no instinct corresponding to maternal jealousy exists amongst these animals, a female bearing eggs is placed at such a physical disadvantage, that it is not unlikely that she would be more cautious of entering a confined space with other lobsters. At any rate, this consideration should be borne in mind when drawing conclusions from the results arrived at by Ehrenbaum.

An examination, made at the end of July, of the ovary of a female whose brood had just been hatched, did not appear to me, in itself, to offer evidence for or against the view that eggs would not be laid even during the same summer. The ovaries were found to extend from the anterior end of the œsophagus to the middle of the third segment of the abdomen. The eggs were of a dark green colour, and in a lobster 30.5 cm. long, many of them had a diameter of as much as 1.2 mm. If no further evidence of a different kind were forthcoming, one would, I think, have been inclined to expect that these eggs would be laid during the same summer. It seems to be very important for the settlement of these questions that the rate of development of the eggs in the ovaries of lobsters kept under conditions as normal as possible should be determined, but this, of course, involves many difficulties. It could, probably, only be satisfactorily undertaken where the lobsters could be confined in a large tidal pond from which they were unable to escape but from which the water could at intervals be drawn off completely.

The number of eggs laid by a lobster becomes very much greater as the age of the animal advances. This appears to be true, both of the American and European species. A female 8 inches long, according to Herrick, carries from 3,000 to 9,000 eggs, whilst in one measuring 16½ inches, the number was 85,000. As the result of an examination of nearly a thousand individuals, this author finds that "the numbers of eggs produced by a female lobster at each reproductive period vary in geometrical series, while the lengths of the lobsters producing these eggs vary in arithmetical series."

Thus an American lobster

8	inches	long	produces	5,000	eggs.
10	„	„	„	10,000	„
12	„	„	„	20,000	„
14	„	„	„	40,000	„
16	„	„	„	80,000	„

Ehrenbaum finds a similar state of things in the Heligoland lobster, although the actual number of eggs on individuals of the same length appears to be less in the European than in the American species. The following table gives the German naturalist's chief results on this head*:

Total length of Lobster.	Number of eggs counted.	Estimated number of eggs, including those lost after animal is caught.
25.4 cm. (10 inches)	7,026	8,000
28.1 cm. (11$\frac{1}{16}$,,)	7,376	8,000—8,500
29.1 cm. (11$\frac{1}{2}$,,)	8,420	9,009—9,500
29.5 cm. (11$\frac{5}{8}$,,)	13,532	14,000
29.2 cm. (11$\frac{1}{2}$,,)	10,330	11,000
31.0 cm. (12$\frac{2}{5}$,,)	16,800	17,500
31.1 cm. (12$\frac{1}{2}$,,)	10,307	11,000
35.5 cm. (14 ,,)	20,016	22,000
37.3 cm. (15 ,,)	29,000	32,000

An account of the number of eggs produced by the individual leads to the consideration of what Herrick calls the "law of survival of the larvæ." From the figures given for the American species, it is evident that the total number of eggs produced during the entire life of a female which reaches the length of 16 inches, must be very large, even should Ehrenbaum's conjecture that spawning takes place only once in four years prove to be correct. The question which presents itself is, what proportion of this large number of eggs must develop into sexually mature lobsters, in order to maintain the species in its existing numbers; and the answer to this question would be completely given if we knew (1) the relation of the total number of females existing to the total number of males, and (2) the number of eggs produced on the average by a sexually mature female during the whole of her life; for it is only necessary that each female should give rise to two sexually mature individuals in order to accomplish the result, if the number of males is not greatly in excess of the number of females.

It is known, from observation, that the males are not greatly in excess, but the average number of eggs produced by females during the course of their lives is more difficult to ascertain, as we have no knowledge of the number of individuals destroyed at different ages. Many, no doubt, of those which lay their first brood are destroyed before the eggs are hatched, whilst of those which survive, a constantly diminishing number produce a second, third, or fourth lot of young. This, however, is in part compensated by the fact that the number of eggs produced increases so rapidly with the increase in size of the lobster.

---

* In comparing Ehrenbaum's figures with those of Herrick, it must not be forgotten that those of the latter author are based on an examination of nearly a thousand individuals, whilst those of the former are in each case the result of counting the eggs of a single female.

Herrick makes the exceedingly moderate statement that, taking into account "the fact that the species, as a whole, does not appear to be maintained at present at an equilibrium, but rather to be actually on the decline, a little reflection will convince anyone that the destruction of the young of this species in nature, must be much greater than that entailed by the survival of 2 in 10,000."

But this estimate appears, from a consideration of all the facts, to be considerably too low, and we should, I believe, be well within the mark in placing the figures at 2 in 30,000. It must not be lost sight of that the number of eggs that it is necessary for a female to produce to maintain the species at an equilibrium, in other words, the number of eggs actually produced by each female, had become a fixed quantity before there was any interference on the part of man in the way of lobster fishery, as we must suppose that the species was then adapted to its conditions. But, since the introduction of lobster-fishing has done nothing to increase or diminish the dangers to which the larva is exposed after it has become free,* the number of eggs now produced, on an average, by a female lobster during her lifetime, will give us an indication of the minimum number of eggs necessary, in order to ensure the survival to sexual maturity of two individuals.

From the *Report of the Newfoundland Department of Fisheries* for 1893, p. 39, it appears that from a total of 96,098 female lobsters taken from 1890 to 1893, the number of eggs collected was 2,247,908,000, which would give an average of 23,000 eggs for each female. This is the average number of eggs actually carried. But a female with 23,000 eggs would, according to Herrick's results, have a length of more than 12 inches, and would, therefore, from the known average age at which spawning commences, be carrying, at least, her second brood. Under these circumstances 30,000 eggs, on the average, to each female during her lifetime, must be well within the mark and the number of survivors necessary, therefore, to maintain the species cannot be more than 2 to every 30,000 eggs.

As Herrick points out, attempted remedial measures, which are confined to the mere hatching of lobster eggs, and turning the larvæ immediately into the sea, can have but little practical effect. The rate of destruction will be at least as great as in the case of larvæ hatched by the parent, and, on the estimate given above, two, at most, will survive out of every 30,000. This method of attempting to benefit the lobster industry has been extensively used in Newfoundland, and it is interesting to calculate what the probable effect of the operations there being carried on is likely to be.

---

* It may, of course, be maintained that the capture of other fish has tended to reduce he number of enemies of the larvæ.

From the *Report of the Newfoundland Department of Fisheries* for 1893, it appears that the largest number of ova dealt with in any one year was 696,517,690, in 1891. Calculating the number of survivors at 2 in 30,000 (as a matter of fact, 20 per cent. were lost before hatching, a much greater number than would be lost under natural conditions), this would give 46,434 adult lobsters added to the neighbourhood. Even if all these 46,434 were caught, the percentage of increase on the whole fishery (a little over 5,000,000 in 1893) would be 0·9 per cent.

A consideration of the steps by which this conclusion has been reached will, I think, leave the impression that it is still far too high, and that a very much smaller percentage would much more nearly represent the truth. As to whether the result is sufficient to justify the trouble and expense involved in bringing it about, I will not venture to express an opinion.

If the larvæ could be reared through their early pelagic stage and not liberated until their natural instincts lead them to seek the bottom and hide themselves, the result would, as Herrick maintains, be probably very different; but if this could be successfully done on a large scale, as no doubt it might be if sufficient capital were put into the undertaking, there seems no reason why the young lobsters should not be reared to the adult stage, and to marketable size, and not turned into the sea at all. An undertaking of this kind, carried out on a scale similar to that upon which oyster-farming is conducted on the Continent, might very probably be made a success.

Additional Observations on the Nerve-Elements of the Embryonic Lobster.

By

E. J. Allen, B.Sc.
Director of the Plymouth Laboratory.

In Vol. III., No. 3, p. 208, of this Journal, a summary was given of certain observations made in the Plymouth Laboratory on the nerve-elements of the embryonic lobster. A more detailed description of these elements, with figures, appeared in the *Quarterly Journal of Microscopical Science*, vol. 36, 1894. The observations have since been extended, and the following summary of the additional results may not be without interest.

In the detailed paper a pair of elements (Element B) was described occurring in the ganglia Thorax II., Th. V., and Th. VIII., each of which consisted of a cell lying in the lateral mass of ganglion cells, which gave off a fibre decussating with its fellow of the opposite side, and then running forward to the brain. Before leaving the ganglion in which the cell lay, the fibre gave off a pair of branches, one going to the ganglion immediately in front, the other to the ganglion immediately behind, the branches breaking up in the neuropile of each of these ganglia. Thus Element B, in Th. II., sent a branch to Th. I. and to Th. III.; Element B, Th. V., sent branches to Th. IV. and Th. VI.; Element B, of Th. VIII., sent branches to Th. VII. and Th. IX., the main fibres running forward to the brain.

A precisely similar element has since been found in Th. XI., sending branches to Th. X. and Abd. I., so that the series is now complete for the thorax, and each of its ganglia appears to be influenced by these elements, the fibres of which arboresce in a particular region of the brain.

A number of additional motor fibres, which cannot well be described without drawings, have also been observed in the thorax, some of which resemble those figured in the former paper, whilst others differ from them in essential details. Some of these motor elements send their fibres out of the cord through the anterior nerve roots, others through the posterior.

The motor elements previously described are all characterised by the fact that the fibre leaves the central nervous system through one of the roots of that ganglion in which the cell attached to it is situated. The portion of the element which lies within the central nervous system is therefore entirely confined to one ganglion. In a number of elements, which have since stained, whilst the cell lies in one ganglion, the fibre passes out of the cord by the nerve-root of some other ganglion. In one such element, the cell lies in the anterior portion of the central mass of ganglion cells of Th. VII., and gives off a fibre which runs outwards and then upwards, to Th. VI., where it passes out by the posterior root of the ganglion. The fibre gives off a stout arborescent branch in Th. VII., and a straight transverse branch in Th. VI., which passes across to the opposite side of that ganglion.

Of elements belonging to new types, perhaps the most interesting are those which, taking origin in a single cell, have two or more branches, which pass out of the central nervous system by the nerve-roots of different ganglia. For example, a cell lying in the anterior portion of the lateral mass of ganglian cells of Thorax VIII., gives off a moderately fine fibre, which very soon bifurcates, one branch passing immediately out of the ganglion through the anterior nerve-root, whilst the other runs forwards along the ganglionic cord. The forward branch pursues a perfectly straight course until it reaches Th. III., where it gives off a branch, which passes out through the posterior root of that ganglion. After giving off this branch the fibre continues to Th. II., where it turns and leaves the ganglion through the posterior root. Hence this element, the cell of which lies in Th. VIII., supplies fibres to at least three nerve-roots of different ganglia, namely, the anterior nerve-root of Th. VIII., the posterior root of Th. III., and the posterior root of Th. II., and all these fibres have their origin in a single cell.

In the *Abdominal Ganglia*, staining of nerve elements can be obtained in two ways. In the case of embryos in the early or medium stage, fibres which have taken up the methylene blue in the thorax, often continue to absorb the colouring matter in the abdomen, and the cells with which they are connected are thus brought to light. The best results for the abdominal ganglia can, however, be obtained by special preparation of embryos, which are very near the hatching point. In such embryos the abdominal ganglia may be dissected out from the surrounding tissue by careful manipulation with needles. Special care must be taken not to injure or stretch the ganglia, and their continuity with the ganglia of the thorax should be maintained. If the embryo, thus prepared, be placed with the dorsal surface uppermost in very dilute methylene blue, satisfactory staining of many of the elements of the abdomen will soon take place.

The elements of the abdomen belong to types similar to those described for the thorax.

In each ganglion a pair of elements exists, taking origin in two ganglion cells lying upon opposite sides. Each cell gives off a fibre, which after decussation with its fellow, passes to the opposite side of the ganglion, and gives off a branch to the neuropile. It then turns forward and runs along the cord to the brain. In this way each of the ganglia of the abdomen is placed in direct communication with the brain.

In the sixth abdominal ganglion two pairs of elements of this type occur, thus pointing to the composite nature of the ganglion.

A considerable number of motor elements, consisting of a cell in one of the ganglia, and a fibre which passes out of the central nervous system, have stained in the abdomen. These are of two kinds; first, those in which the element is confined to a single ganglion, the fibre passing out through one of the roots of the ganglion in which the cell lies, and secondly, those in which the fibre leaves the central nervous system by a nerve-root of a ganglion other than that in which the cell lies. These will be described in detail in a later paper.

Further observations have also been made on the sensory nerve elements, which have their origin in cells lying outside the central nervous system. These fibres, on entering a ganglion, make a characteristic Y-shaped bifurcation, sending one branch forwards and the other backwards along the cord. These branches have been traced for considerably greater distances than was previously possible, the forward one having been seen to pass through at least nine or ten ganglia. In all probability, all these forward branches go in every case to the brain. The backwardly directed branch has never been actually traced through more than two or three ganglia, and no indication has been obtained as to the locality or nature of its termination.

A detailed account of the observations here recorded will be published in the *Quarterly Journal of Microscopical Science.*

Notes and Memoranda.

On a Specimen of Leptocephalus Morrisii.—During the first week of June of the present year, a specimen of *Leptocephalus* was brought to the Laboratory by a boy, who had found it under a stone on the shore, in a small cove in front of the building. The beach in this cove consists of broken fragments of limestone. The specimen was alive when brought up, and was preserved in formaldehyde. When I examined it a few weeks later it was entire and in excellent condition, and retained its transparency to a considerable degree in the preserving liquid. The specimen is 11.25 cm. long (4½ in.); the greatest dorso-ventral breadth of the body, a little behind the anus, is 7 mm.; the breadth in the same direction at the back of the head is 5 mm. The dorsal line rises slightly behind the head. From the tip of the lower jaw to the anus the distance is 5.25 cm., from the tip of the snout to the commencement of the dorsal fin is 3.6 cm. Thus the point at which the dorsal fin commences is nearer to the anus than to the pectoral fin, although, in the fully developed conger, the dorsal fin extends forwards to a point in front of the posterior extremity of the pectorals. In this respect the larval form more resembles the adult common eel (*Anguilla*) than its own parent. The greatest lateral thickness of the body is just behind the head, and does not exceed 2 mm. Behind the anus it is narrower still. The head, however, is not much compressed laterally, but is rather broad, and flat on the dorsal surface. The length of the head is 8 mm., measured from the tip of the snout to the gill opening; its breadth is 3 mm.; its vertical height at the level of the eyes, 4 mm. In characters the head resembles that of the conger very closely. The eyes are large, the exposed front being silvery, except along the dorsal edge, where there is a streak of black pigment. The anterior tubular nostrils and the posterior open ones are present, as in the conger, and the gill opening is a reduced slit in front of the base of the pectoral, as in the latter. The upper jaw is a little longer than the lower, and the angle of the mouth is below the middle of the eye. No bones can be seen in the interior of the body by this examination of the entire animal without further preparation; the myotomes are distinct, numerous, and narrow antero-posteriorly. There are simple, slender, permanent fin rays in the longitudinal fin; I counted 480 of these, but at the anterior extremities of the fin they were too indistinct to be counted accurately. The end of the tail has the same shape as in the adult conger, the fin passing continuously round it, and the rays being arranged symmetrically and somewhat more elongated than in the dorsal and ventral parts of the fin. The pectoral fin is 3 mm. long.

There is a single linear series of black dots along the middle of each side, each dot being a single stellate chromatophore. There are a few additional chromatophores below the principal series, and also a row along each side of the middle ventral line of the abdomen. At the base of the longitudinal fin, there is a series of chromatophores on each side, one to each fin-ray, continued round the end of the tail to a point about ½ in. from the apex of the tail dorsally, but there are none on the rest of the dorsal edge of the body.

In most respects, as may be seen on comparing the above description with Couch's figure, our specimen agrees well with the latter. The characters of the head are not, however, well brought out in that figure. Judging from our specimen, the eyes are too small, and the character of the mouth and jaws is not shown; the whole head is also too small. In Couch's figure, too, the body increases more in breadth towards the middle region and in the posterior half than in our specimen, in which the dorso-ventral breadth remains almost uniform in the middle two-thirds of the body, decreasing anteriorly and posteriorly.

Further anatomical examination must be deferred to some other opportunity. I will only add here that the character of the larva suggests to myself the idea that it corresponds to special conditions of life, as is the case in other larvæ, and that these special conditions are not of the pelagic kind. The head is, to all intents and purposes, the head of a conger, and the like may be said of the longitudinal fin, with the reservation mentioned above. The body is compressed, colourless, transparent, and boneless, and these qualities would, I think, be fostered, if not produced, by the habit of living under stones and in narrow crevices, with comparatively little exertion of the trunk musculature.

J. T. Cunningham.

Cuthona ? aurantiaca.—I am glad to be able to add this beautiful species to the *Nudibranchiate* fauna of Plymouth. Two specimens were found amongst some dredging from the Millbay channel, on February 6th, 1895. On the same stone there was a colony of *Antennularia ramosa,* which most likely formed the food of the *Nudibranch.* One of the specimens had deposited spawn on the same stone. The interest of this lies in the fact that Alder and Hancock mention this animal as spawning in June and July, whereas this specimen spawned on or about the 6th February. I think there can be no doubt that this spawn belongs to the *Eolid,* as it exactly answers Alder and Hancock's description of it, and, moreover, no other *Nudibranchs* were found in the dredging. During the short time I kept these animals alive, like so many other *Eolids,* they exhibited a partiality for floating on the surface of the water, foot uppermost.

J. C. SUMNER.

Director's Report.

The issue of the present number of the Journal, which commences Volume IV. of the New Series, has been delayed in consequence of the publication of the Special Number containing Mr. Holt's memoir on "An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish," which was issued to members in June. I am glad to be able to state that this special number has met with a most favourable reception. It is recognised on all hands that Mr. Holt's memoir constitutes the most serious and successful attempt which has been made for some time past, to place before the general public an accurate and scientific account of the facts relating to one of our most important industries.

As the reports now published show, Mr. Cunningham has continued to carry forward the investigation of the North Sea fishing grounds, and his observations form an important contribution to our knowledge of the subject.

During the time which has elapsed since the appearance of the last regular number of the Journal, the work of the Association at Plymouth has suffered somewhat from the difficulty experienced in obtaining the services of a suitable naturalist to carry on the fishery investigations, which it had been hoped that Mr. Holt would have been able to undertake. The difficulty is, I am glad to say, no longer present, Mr. F. B. Stead, B.A., of King's College, Cambridge, having been appointed by the Council to carry on this branch of our work. An addition to the regular staff has also been made by the appointment of Mr. T. V. Hodgson to the post of Director's Assistant. A. J. Smith, from the Cambridge Morphological Laboratory, has held the position of Laboratory attendant since the beginning of April, and in a large measure has charge of the preservation of specimens for sale. It is hoped that by improving the quality of the specimens sent out by the Association, the demand for them will become greater and our usefulness in this direction extended.

Considerable expense has been incurred in overhauling the engines and pumps, and putting them into a state of proper working order.

The ejector, used for forcing water from the sea, has again been a source of trouble. The iron rod supporting the lower bucket of the automatic valve had rusted so seriously, that it was no longer able to bear the weight, and the bucket became detached. In order to repair this defect it was necessary to remove the cover of the lower chamber of the apparatus, an undertaking of some difficulty. The matter has, however, now been put right, the iron rod having been replaced by one of Muntz metal, which, it is hoped, will better resist the action of the sea-water. The engines and rotary pumps are also being put into a state of thorough repair.

The new system adopted for supplying the tanks in the Laboratory with sea-water has shown itself to be a decided improvement upon that originally used. It may be of interest to describe somewhat in detail the method now employed. Water is pumped from the sea at high tide—when possible, only at the highest spring tides—into one of the large underground reservoirs. From thence it is pumped twice daily into the tanks in the centre of the Laboratory upstairs. In the intervals between the pumpings (twelve hours) these tanks are allowed to empty themselves about one-half, the water running from them falling into the Aquarium below. The Aquarium, however, is supplied principally by a constant circulation of water from the second underground reservoir, which thus becomes gradually renewed by the water falling into it from the Laboratory. By this arrangement the water supplied in the Laboratory is such only as has not previously been used, whilst at the same time the water in the second reservoir and the Aquarium is constantly replaced by water from the sea.

There can be no doubt that the water now in the tanks upstairs is much better for delicate work than that in the general circulation of the Aquarium. Foraminifera, which formerly did not develop normally in the water, can now be satisfactorily reared, and colonies of hydroids have sprung up on the sides of the tanks. Two shallow wooden tanks, placed immediately under the windows on the south side, have been especially successful. Green weeds have sprung up all around their sides, together with a few tufts of red weeds, and numerous colonies of hydroids, serpulids, and compound ascidians. In these tanks the most varied animals, including Hydractinia, Sponges, Echinus, Aplysia, and Ascidians have remained quite healthy for several months, and appear to be still in the same condition. From this and other experiments which I have made, I feel little doubt that the direct action of sunlight upon a portion, at least, of the water is an important factor in keeping it in a satisfactory condition to support the more delicate forms of animal life. It is only in the presence of sunlight also that seaweeds will grow, and in an aquarium where these grow in quantity a much more abundant supply of the minute forms of animal life, which serve as food for the larger, is invariably found.

A commencement has been made on the work of re-arranging and completing the type collection of specimens in the Museum. Several groups are approaching completion, and it is hoped that before long we shall have a representative series of the fauna and flora of the neighbourhood.

Two valuable additions have been made to the Library through the kindness of Sir William Flower, and of the Director of the Royal Gardens at Kew. To the former we are indebted for a complete set of the *Philosophical Transactions of the Royal Society* from 1857 to 1886, and to the latter for a bound copy of Buffon's *Histoire Naturelle.* The Library is still very incomplete, and any addition to it will be much valued. Situated as we are, so far from London, and from any scientific library of importance, it is very necessary that our own supply of literature, both zoological and botanical, should be as complete as possible. A large number of standard works we, unfortunately, do not yet possess.

The outdoor work of the Association has been regularly carried on, and several captures of interest have been made. The sailing boat, *Anton Dohrn,* has been used for work in the Sound, and the small steam tug, *Lorna,* has been hired for work outside. This boat, however, although very suitable for short distances, is not sufficiently large to make expeditions of any length. A short account of the most noteworthy features of the fauna, and the most interesting captures which have been made, will be found in another part of the present number of the Journal.

We have been fortunate in obtaining from the Government Grant Committee of the Royal Society, a grant towards the expenses of boat hire in connection with an attempt to extend our dredging and trawling work to the deeper water lying between Start Point and the Eddystone. The unsettled weather of the past month has interfered, to some extent, with this work, but the results so far obtained give promise of the discovery of valuable collecting grounds, which would be within our reach if we had a suitable boat to visit them. These investigations will be continued at every available opportunity during the summer, and it is hoped that some, at any rate, of the results will be ready for publication in the next number of the Journal.

I am glad to be able to state that the number of workers who have made use of the Laboratory has somewhat increased. The complete list from the beginning of the year is as follows:—

J. C. Sumner, January 2nd to February 28th *(Echinoderm fauna).*

R. Assheton, M.A., February 1st to February 15th *(Elasmobranch development).*

E. S. Goodrich, B.A., March 20th to April 4th *(General Zoology)*.

L. J. Picton, March 20th to April 4th *(General Zoology)*.

T. H. Taylor, March 23rd to April 13th *(Polyzoa)*.

W. Garstang, B.A., March 21st to May 1st *(Tunicata)*.

G. W. Butler, M.A., April 3rd to May 17th *(Teleostean development)*.

Prof. C. C. Nutting, April 12th to May 20th *(Hydroids)*.

T. H. Riches, B.A., April 13th *(Nemerteans)*.

T. V. Hodgson, May 27th to June 9th *(Amphipoda)*.

Dr. P. Barthels, May 28th to June 8th *(Echinodermata)*.

W. Garstang, M.A., June 26th to July 31st *(Tunicata)*.

S. P. Bedford, June 29th to August 1st *(General Zoology)*.

J. E. Gray, July 2nd to August 1st *(General Zoology)*.

Prof. W. F. R. Weldon, F.R.S., June 29th *(Variation of Carcinus mænas*.

Dr. A. Bethe, July 5th *(Nervous System of Crustacea)*.

J. Bancroft, July 8th to July 30th *(General Zoology)*.

G. P. Bidder, M.A., July 11th *(Sponges)*.

W. J. Beaumont, B.A., July 17th *(Faunistic investigations)*.

J. D. Gilchrist, Ph.D., July 20th *(Nervous System of Mollusca)*.

Amongst the workers we have been glad to welcome the three foreign naturalists who have visited us. Prof. Nutting, of the State University of Iowa, was engaged for some six weeks on the study of the Hydroids found at Plymouth, and succeeded in finding not only several species new to the Plymouth fauna, but also in making a number of interesting observations on the structure of the *Plumularidæ*, a family to which he is devoting special attention. It is hoped that the next number of this Journal will contain a paper by Prof. Nutting, embodying some of his more important results.

Dr. P. Barthels, from Prof. Ludwig's Laboratory in Bonn, was occupied chiefly in the preservation of *Echinoderms* for future study, whilst Dr. Bethe, from Prof. Hertwig's Laboratory in Munich, is engaged in a physiological study of the nervous system of *Carcinus mænas*, side by side with an investigation of the minute anatomy of that structure. The latter researches are of particular interest, as they are being made with the aid of the new method which Dr. Bethe has devised for fixing methylen blue preparations with *Ammonium molybdate*. This method is, without doubt, destined to play a most important part in future studies of the minute histology of the nervous system of many forms. There can be no question that it is superior to any means yet devised for rendering the results of methylen blue staining permanent, and it has the immense additional advantage that sections of the preparations can be made after imbedding in paraffin in the usual way.

The list of persons working at the Laboratory also includes five students from Oxford and Cambridge, who have visited us during their vacations, and have engaged in general study of the animals found here, under the direction of Mr. Garstang. This is, I am convinced, a useful extension of the work of the Laboratory, as the study of living animals, under their natural conditions, has not in the past received that attention at the Universities which is due to it. The students who have worked here have, I believe, acquired a very valuable additional insight into their subject, and a few weeks spent, as it were, in the midst of a marine fauna, cannot but have a beneficial influence on their future studies. It is to be hoped that in future years many more students will visit us in this way, and that those who have been here already will return to carry on research.

Professor Weldon has been engaged in an attempt to determine the difference in the amount of abnormality in individual crabs at different ages. In order to do this, it has been necessary to fit up an apparatus, by means of which some 500 crabs can be kept in separate bottles, with a current of sea-water running through each bottle. To keep these bottles properly cleaned, and the crabs fed daily, has involved a very considerable amount of labour, and as, in addition to this, the individual crabs have to be measured at at least two different ages, the whole investigation is one which can only be carried on at the expense of a great deal of time and energy. Whatever conclusion, however, may be arrived at as the result of the measurements, there can be no doubt that the knowledge gained will be worth any trouble entailed in obtaining it.

On another page will be found Mr. Butler's account of his observations on the breeding of the soles in the Aquarium. As Mr. Butler points out, this is the first occasion since the Aquarium was opened that these fish have been known to produce fertilised eggs, and is probably the first time that such eggs have been obtained from specimens of this fish kept in confinement.

Considerable progress has been made in arranging certain groups for the type museum by the three gentlemen, Messrs. Garstang, T. H. Taylor and T. V. Hodgson, who have undertaken this work. There still remains much to be done, and it is hoped that other naturalists will be willing to take advantage of the arrangements made for helping with other groups.

E. J. ALLEN.

August, 1895.

Marine Biological Association of the United Kingdom.

Report of the Council, 1894-95.

The Council.

The Council has met on ten occasions during the past year for the transaction of the business of the Association. The average attendance at the meetings has been 7·5. Meetings of Special Committees have also been held as occasion required.

For various reasons, it is proposed in the future to hold only four Council Meetings in each year, unless special occasion should arise for increasing their number.

Dr. A. Günther, F.R.S., who had been a member of the Council since its formation in 1884, resigned his seat in the course of the Session, owing to pressure of other occupations, and was elected a Vice-President of the Association. Mr. G. C. Bourne, of New College, Oxford, was elected to fill his place.

The Council has again to acknowledge the courtesy displayed by the Royal Society and the Linnæan Society, in permitting the meetings of the Association to be held in their rooms.

The Plymouth Laboratory.

The defects in the large reservoirs, referred to in the last Report, have been made good by draining and cementing on the south side.

Some considerable trouble was given last year by a fracture in the large pipe which leads seawards from the ejector; this had been presumably caused by a vessel having dragged her anchor over it; the repairs, which necessitated the employment of a diver, have been carried out satisfactorily.

The Council is now able to give a satisfactory report of the condition of the buildings, fittings, and machinery of the Laboratory.

The Boats.

During the past year the greater part of the work of collection of specimens at sea has been carried out by hired steam-tugs, supplemented whenever possible by the Association's sailing-boat, the *Anton Dohrn.* The small steam-launch *Firefly,* which was most serviceable for this purpose for many years, has been at last sold for breaking up.

The Council greatly regrets that there is no immediate likelihood of the Association procuring a suitable boat for deep-sea work.

The Library.

All the most important annual publications relating to Sea Fisheries are now in the Library, both official publications of most Governments, and publications of fishery societies and local authorities. Several memoirs, containing the results of marine explorations, have been added during the past year, notably the two concluding volumes of the *Challenger* Reports; there have also been added memoirs from the German Plankton Expedition, the cruises of H.M.S. *Investigator,* in the Bay of Bengal, the Commission for Investigation of the German Seas, and the Bahama Expedition of the Iowa State University. The Association has also received, by gift and exchange, the publications of the Royal Societies of London and Edinburgh, the Zoological Society, the Royal Microscopical Society, the Society of Arts, and numerous other scientific societies, academies, and museums at home and abroad. To these, and to the many donors of books and papers, the Council take occasion to render the thanks of the Association.

The Museum and Exhibition Series.

Although a good deal has been done in the Museum during the past year, much remains still to be done; and the Director has been fortunate in obtaining promises of assistance from various naturalists in this important work during the coming summer.

The series of specimens mounted for exhibition, to which reference has been made in the last two Reports of the Council, was shown at the meeting of the British Association at Oxford, in 1894, and is at present at the Scarborough Fishery Exhibition, together with a set of dredges, trawls, and tow-nets.

The Staff.

Several changes have occurred lately in the Staff. Mr. E. J. Bles resigned the post of Director on October 11th, 1894; and Mr. E. J. Allen, B.Sc., University College, London, who had long been a worker at the Laboratory, succeeded him on January 12th, of this year.

Mr. Cunningham is at present stationed at Grimsby.

Mr. E. W. L. Holt was unfortunately compelled, by ill-health, to leave the Association's service in March last, and Mr. Stead has been appointed for the term of one year, to carry out, for the Plymouth district, statistical and other inquiries similar to those upon which Mr. Holt has been engaged at Grimsby.

Mr. J. P. Thomasson, to whose generosity the Association has been so largely indebted in previous years, has renewed his donation of £250, for fishery investigations on the North Sea for another year, commencing in March last.

General Report.

Mr. Holt concluded his work at Grimsby in the winter, and has since then prepared an account of his observations on the North Sea Fisheries during the past three years, in a more popular form than the technical papers which he has contributed to the Journal. This summary, which gives a most valuable and unique picture of the present state of the Fisheries, and should prove of great value in the event of protective legislation, has been printed as a special number of the Journal, and reprinted for sale and distribution.

Mr. Cunningham has prepared for press a natural history of marketable sea fish, to appeal to a wider public than the Journal can attract, which will also be issued as a special number of the Journal, and reprinted for distribution and sale. This memoir is especially designed for the use of the Sea Fisheries' Committees controlling the fisheries of the English coast.

In addition to the preparation of this memoir, Mr. Cunningham has continued his investigations into the rate of the growth of fishes, and the minute structure of the eggs and ovary; he has also carried out further experiments in the relations between light and colouration of fishes.

The water in circulation at the Laboratory has lately improved very greatly in quality under a new system of working introduced by the present Director. Whether as a consequence of this or not, the soles in the aquarium have bred this spring for the first time; no previous record is known of soles having bred naturally in confinement.

After June 30th, the arrangement will terminate, by which the Association has made an annual contribution to the Marine Fisheries Society (Grimsby) in return for the use and control of the Cleethorpes Aquarium by Mr. Holt.

The following interesting additions have been made to our knowledge of the Plymouth Fauna during the past year:

Tiaropsis diademata.
Halecium tenellum.
Plumularia halecioides.

Syncoryne mirabilis.
Aplidium zostericola.
Amaræcium punctum.
Distaplia rosea.
Circinalium concrescens.

Corymorpha nutans, of which no specimens have been taken since 1887, has lately been captured on two occasions.

Occupation of Tables.

The following naturalists have occupied tables in the Plymouth Laboratory during the past twelve months:

E. J. Allen, B.Sc., University College, London (Nervous System of Crustacea).
R. Assheton, M.A., Cambridge (Elasmobranch Development).
G. P. Bidder, B.A., Naples (Porifera).
E. T. Browne, B.A., University College, London (Variation of Aurelia).
G. W. Butler, B.A., Chertsey (Teleostean Development).
G. P. Darnell-Smith, B.Sc., Bristol (Physiology of Algæ).
W. Garstang, M.A., Oxford (Tunicata).
E. S. Goodrich, Oxford (General Zoology).
M. D. Hill, B.A., Oxford (Molluscan Ova).
J. J. Lister, M.A., Cambridge (Development of Foraminifera).
Prof. C. C. Nutting, State University, Iowa (Hydroids).
T. H. Riches, B.A., Plymouth (Development of Nemertines).
J. C. Sumner, Royal College of Science, London (Echinodermata).
T. H. Taylor, Yorkshire College, Leeds (Polyzoa).

Surgeon P. W. Bassett-Smith, R.N., Plymouth, and Mr. L. J. Picton, Oxford, have also made use of the Laboratory, without formal occupation of a table.

The following papers, either wholly or in part the outcome of work done at the Plymouth Laboratory, or by members of the Staff stationed elsewhere, have appeared during the past year, in addition to those published in the Journal:

Browne, E. T.—*On the Variation of the Tentaculocysts of* Aurelia aurita, Quart. Journ. Micr. Sci. xxxvii. 245.

Garstang, W.—*On the Gastropod* Colpodaspis pusilla *of Michael Sars*, Proc. Zool. Soc. November 20th, 1894.

Sumner, J. C.—*Description of a New Species of Nemertine*, Ann. and Mag. of Nat. Hist. ser. 6, vol. xiv.

Weldon, W. F. R.—*An Attempt to Measure the Death-rate due to Selective Destruction of* Carcinus mænas, *with Respect to a Particular Dimension*, Proc. Roy. Soc. lvii. p. 360.

Donations and Receipts.

The Receipts for the past year include the annual grants from H.M. Treasury (£1000) and the Worshipful Company of Fishmongers (£400); and a special donation of £250 from Mr. J. P. Thomasson for the prosecution of fishery investigation. Other sources of income have been—the annual subscriptions (£135), composition fees (£25), rent of tables in the Laboratory (£39), sale of specimens (£205), and admission to the Aquarium (£66); the total amounting, with lesser sums, to £2178.

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1895–96:—

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G. K.T., F.R.S.
The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Revelstoke.
The Right Hon. Lord Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Sir John Lubbock, Bart, M.P., F.R.S.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Sir Wm. Flower, K.C.B., F.R.S.
A. C. L. G. Günther, Esq., F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson.
Admiral Wharton, R.N., F.R.S.

Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffery Bell, F.Z.S.
G. C. Bourne, Esq., F.L.S.
Sir John Evans, K.C.B., Treas. R.S.
G. Herbert Fowler, Esq.
S. F. Harmer, Esq.
Prof. W. A. Herdman, F.R.S.
Prof. S. J. Hickson, F.R.S.
J. J. Lister, Esq.
Prof. W. C. McIntosh, F.R.S.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
D. H. Scott, Esq., F.R.S.
Prof. Charles Stewart, V.P.L.S.
Prof. W. F. R. Weldon, F.R.S.

Hon. Treasurer:

E. L. Beckwith, Esq.

Hon. Secretary:

E. J. Allen, Esq., The Laboratory, Plymouth.

Dr. *Statement of Receipts and Expenditure for the Year ending 31st May, 1895.* Cr.

Receipts.		£ s. d.	£ s. d.
To Balance from last year, being Cash in Bank and in hand (General Fund, and Bait Investigation Fund)			10 1 5
,, H.M. Treasury			1000 0 0
,, Fishmongers' Company (this includes £200 for the year 1895-96)			600 0 0
,, To Special Donation, J. P. Thomasson, Esq.			250 0 0
,, Annual Subscriptions			135 9 0
,, Composition Fees and Donations			25 15 0
,, Rent of Tables	£ 39 11 0		
,, Sale of Specimens	205 12 10		
,, Sale of *Journal*	19 9 8		
		264 13 6	
,, Sale of Monograph		3 10 0	
,, Sale of Launch *Firefly*		6 0 0	
,, Admission to Tank Room		66 17 0	
,, Interest on Investment		25 18 9	
			366 19 3
			£2388 4 8

Examined and found correct,

Stephen E. Spring Rice,
Frank E. Beddard,
F. Jeffrey Bell,
Edwin Waterhouse,
} *Auditors.*

Expenditure.		£ s. d.	£ s. d.
By Salaries and Wages—			
Director		200 0 0	
,, ,, allowance for Assistant		80 0 0	
,, Naturalist, Mr. J. T. Cunningham		250 0 0	
,, ,, Mr. E. W. L. Holt		100 0 0	
,, Wages		335 10 2	
			965 10 2
,, Stationery, Office Printing, Postages, &c.			159 19 10
,, Printing Journal		91 16 0	
,, Illustrating ,,		2 14 1	
			94 10 1
,, Sundry Expenses—			
Gas, Water, Coal, Oil, &c.		106 19 7	
Stocking Tanks, Feeding, &c.		84 16 6	
Glass, Chemicals, Apparatus, &c.	£133 19 5		
Less Sales to Table Renters	8 0 2		
		125 19 3	
Maintenance, and Renewal of Building, Boats, and Nets		137 11 4	
Rates and Taxes		10 7 2	
Boat Hire		72 16 0	
Travelling Expenses		23 2 0	
Allowance to Naturalist for Expenses of Removal		25 0 0	
Expenses of Exhibition of Specimens		14 14 7	
Library		40 13 5	
North Sea Investigation at Cleethorpes		69 12 7	
			711 12 5
,, Balance forward, being Cash in Bank and in hand (General Fund, and Bait Investigation Fund)			456 12 2
			£2388 4 8

Investment held 31st May, 1895—
£670 Forth Bridge Railway 4 % guaranteed, at 125......£837 10 0

PUBLICATIONS OF THE ASSOCIATION.

JUST PUBLISHED. Royal 8*vo*, 109 *pp.*

AN

EXAMINATION OF THE PRESENT STATE
OF THE
GRIMSBY TRAWL FISHERY,
WITH ESPECIAL REFERENCE TO
THE DESTRUCTION OF IMMATURE FISH.

BY

ERNEST W. L. HOLT,

Late Naturalist on the Staff of the Marine Biological Association.

PRICE ONE SHILLING.

From Messrs. DULAU & Co., 37, Soho Square, London, W.

PUBLICATIONS OF THE ASSOCIATION.

Cloth, 4to, 150 pp., 18 plates (12 coloured).

A TREATISE ON THE COMMON SOLE.

BY

J. T. CUNNINGHAM, M.A., F.R.S.E.,
Late Fellow of University College, Oxford; Naturalist to the Association.

Price to Members, 20*s.*; to Non-Members, 25*s.*
From the Director, The Laboratory, Plymouth, and through all Booksellers.

JOURNAL OF THE MARINE BIOLOGICAL ASSOCIATION.

OLD SERIES.

No. 1, AUGUST, 1887 (only a few copies left, reserved for Libraries).
No. 2, AUGUST, 1888. Price 1*s.*

NEW SERIES.—VOLUME I.

1889–90.

Royal 8vo, xx. and 472 pp., 28 plates.

NEW SERIES.—VOLUME II.

1891–92.

Royal 8vo, x. and 404 pp., 14 plates, 12 woodcuts, and 10 charts.

Price, in neat cloth binding, 15*s.* 6*d.*; to Members, 12*s.*
Separate numbers, in wrappers, 3*s.* 6*d.*; to Members, 2*s.* 8*d.*

NEW SERIES.—VOLUME III. PARTS 1, 2, 3, 4, and SPECIAL NUMBER.

May, 1893; March, 1894; October, 1894; February, 1895; June, 1895.
Separate numbers, in wrappers, 3*s.* 6*d.*; to Members, 2*s.* 8*d.*

From the Director, The Laboratory, Plymouth,
And from the London Agents: Messrs. DULAU & Co., 37, Soho Square, W.

OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Professor LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence, the Association has erected at Plymouth a thoroughly efficient laboratory, where naturalists may study the history of marine animals and plants in general, and where, in particular, researches on food fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent, for the use of a working table in the Laboratory and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter, the payment of servants and fishermen, the hire and maintenance of fishing boats, and the salary of the Resident Director and Staff. At the commencement of this number will be found the names of the gentlemen on the staff. In no case does any one salary exceed £250.

The Association has received some £25,000, of which £11,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £7,000.

The ASSOCIATION IS AT PRESENT UNABLE TO AFFORD THE PURCHASE AND MAINTENANCE OF A SEA-GOING STEAM VESSEL, by means of which fishery investigations can be extended to other parts of the coast than the immediate neighbourhood of Plymouth. Funds are urgently needed in order that this section of the work may be carried out with efficiency. The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS OF NEW SERIES, Vol. IV., No. 1.

PAGE
1. The Right Hon. Thomas Henry Huxley. By Professor E. Ray Lankester, LL.D., F.R.S. 1
2. Report on the Spawning of the Common Sole (*Solea vulgaris*). By Gerard W. Butler, B.A. 3
3. North Sea Investigations. By J. T. Cunningham, M.A. . . 10
4. Faunistic Notes. By E. J. Allen, B.Sc. 48
5. Additional Evidence on the Influence of Light in Producing Pigments on the Lower Sides of Flat Fishes. By J. T. Cunningham, M.A. 53
6. The Reproduction of the Lobster. By E. J Allen, B.Sc. . . 60
7. Additional Observations on the Nerve-elements of the Embryonic Lobster. By E. J. Allen, B.Sc. 70
Notes and Memoranda 73
Director's Report, August, 1895 76
Report of the Council, 1894–95 81

NOTICE.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for statements published in this Journal, excepting when those statements are contained in an official report of the Council.

TERMS OF MEMBERSHIP.

		£	s.	d.
Annual Members .	. per annum.	1	1	0
Life Members . . .	Composition Fee.	15	15	0
Founders . . .	. . .	100	0	0
Governors . . .	. . .	500	0	0

Members of the Association have the following rights and privileges: they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

All correspondence should be addressed to the Director, The Laboratory, Plymouth.

New Series.—Vol. IV., No. 2—issued February, 1896.] [Price 3s. 6d.

11,977

AUG 1896

Journal

OF THE

MARINE BIOLOGICAL ASSOCIATION

OF

THE UNITED KINGDOM.

THE PLYMOUTH LABORATORY.

PLYMOUTH:
PRINTED FOR THE MARINE BIOLOGICAL ASSOCIATION BY W. BRENDON & SON,
AND
PUBLISHED BY THE ASSOCIATION AT ITS OFFICES ON THE CITADEL HILL.
SENT FREE BY POST TO ALL MEMBERS OF THE MARINE BIOLOGICAL ASSOCIATION:
ANNUAL SUBSCRIPTION FOR MEMBERSHIP, ONE GUINEA.
Agents in London:—Messrs. DULAU & Co., 37, Soho Square, W.

PATRON.

H.R.H. THE PRINCE OF WALES, K.G., F.R.S.

OFFICERS AND COUNCIL.

President.

Prof. E. RAY LANKESTER, LL.D., F.R.S.

Vice-Presidents.

The Duke of ARGYLL, K.G., K.T., F.R.S.
The Duke of ABERCORN, K.G., C.B.
The Earl of ST. GERMANS.
The Earl of MORLEY.
The Earl of DUCIE, F.R.S.
Lord REVELSTOKE.
The Right Hon. Lord TWEEDMOUTH.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. JOSEPH CHAMBERLAIN, M.P.
The Right Hon. Sir JOHN LUBBOCK, Bart., M.P., F.R.S.
Prof. G. J. ALLMAN, F.R.S.
Sir EDWARD BIRKBECK, Bart., M.P.
Sir WM. FLOWER, K.C.B., F.R.S.
A. C. L. GÜNTHER, Esq., F.R.S.
Prof. ALFRED NEWTON, F.R.S.
Rev. Canon NORMAN, D.C.L., F.R.S.
Sir HENRY THOMPSON.
Admiral WHARTON, R.N., F.R.S.

COUNCIL.

Elected Members.

F. E. BEDDARD, Esq., F.R.S.
Prof. F. JEFFREY BELL, F.Z.S.
G. C. BOURNE, Esq., F.L.S.
Sir JOHN EVANS, K.C.B., Treas. R.S.
G. HERBERT FOWLER, Esq.
S. F. HARMER, Esq.
Prof. W. A. HERDMAN, F.R.S.
Prof. S. J. HICKSON, F.R.S.
J. J. LISTER, Esq.
Prof. W. C. McINTOSH, F.R.S.
P. L. SCLATER, Esq., F.R.S., Sec. Z.S.
D. H. SCOTT, Esq., F.R.S.
Prof. CHARLES STEWART, V.P.L.S.
Prof. W. F. R. WELDON, F.R.S.

Governors.

ROBERT BAYLY, Esq.
The PRIME WARDEN OF THE FISHMONGERS' COMPANY
E. L. BECKWITH, Esq. (Fishmongers' Company)
Prof. BURDON SANDERSON, F.R.S. (Oxford University).
Prof. MICHAEL FOSTER, F.R.S. (Cambridge University).
Sir WM. FLOWER, K.C.B. F.R.S. (Brit. Assoc. for Advancement of Science).

Hon. Treasurer.

E. L. BECKWITH, Esq., The Knoll, Eastbourne.

Hon. Secretary.

E. J. ALLEN, Esq., The Laboratory, Citadel Hill, Plymouth.

PERMANENT STAFF.

Director—E. J. ALLEN, Esq., B.Sc.

Naturalists.

J. T. CUNNINGHAM, Esq., M.A. | F. B. STEAD, Esq., B.A

Assistant to the Director—T. V. HODGSON, Esq.

VACATION COURSES IN MARINE BIOLOGY.

By arrangement with the Director of the Plymouth Laboratory of the

Marine Biological Association,

MR. WALTER GARSTANG, M.A., F.Z.S.,

Fellow and Lecturer of Lincoln College, Oxford,
and formerly Naturalist to the Marine Biological Association,

WILL CONDUCT

COURSES OF STUDY

IN

MARINE BIOLOGY,

At the PLYMOUTH LABORATORY,

DURING THE EASTER VACATION, 1896,

Between March 23rd and April 24th.

Students and others who may desire to avail themselves of the opportunities that will thus be afforded for a practical study of the life and habits of marine organisms, and of the methods employed for their capture and preservation, should communicate in advance with

MR. GARSTANG,
Lincoln College, Oxford,

who will give any further information that may be required.

Courses of Study similar to the above in

MARINE BOTANY

will be conducted at the same time by

MR. A. H. CHURCH, B.A.,
Jesus College, Oxford,

from whom further particulars may be obtained.

AUG 1896

The Reproductive Maturity of the Common Eel.

By

J. T. Cunningham, M.A.

In the Museum of the Royal College of Surgeons, in London, there are two specimens of the common eel, in which the ovaries are much enlarged, greatly distending the abdomen, and evidently very nearly ripe. Both those specimens were presented by Mr. Geo. Buckeridge, a salesman in Billingsgate Market, who deals largely in eels. The following are certain particulars concerning the specimens :—

(1) Length 15 in., weight 4½ oz. Presented Jan. 4, 1894.

(2) Length 19 in., girth round the abdomen 5½ in., weight 10¼ oz. Presented Sept. 25, 1895.

Both specimens are in spirit, mounted for exhibition, and the ovaries are seen to be of opaque milk-white colour, and generally to present the same appearance as the nearly-ripe ovaries of the Conger described by me in Vol. II. of this Journal. The greatest width of the ovaries is 1⅞ in. or 4·8 cm. The eggs are scarcely visible as distinct grains to the naked eye. Microscopically examined in a small piece which Professor Stewart kindly gave me from the larger specimen, the largest eggs were found to be from ·13 to ·16 mm. in diameter, while the smallest were only ·07 mm. It is a remarkable fact that eggs considerably larger than this have been found in the unripe ovaries of eels in the ordinary condition. Mr. Williamson (*Thirteenth Annual Rep. of Scottish Fishery Board*, 1895) states that in a specimen 70·7 cm. long (28⅓ in.), some of the eggs measured ·27 mm., and several other observers have given the maximum size as ·25 mm. In the ripe specimen described by Rathke, in 1850, the eggs were also small, not exceeding ·2 mm. In the specimen here under description, the microscope showed that the ovarian lamellae were composed almost entirely of ova in close apposition, the adipose tissue so plentiful in the ordinary condition of the ovary having been absorbed. It should be remembered that the eggs were measured after preservation in spirit, which must have caused contraction; but Rathke, who examined his specimen when it was fresh, also remarks that the eggs were distinctly smaller than in eels with small ovaries.

Fig. 1 represents accurately the appearance of the second specimen when mounted, the abdomen having been opened in the mid-ventral line. The figure is printed from a block prepared for the *Field*, and lent to me by the kindness of W. B. Tegetmeier, Esq.

The time of year at which these specimens were obtained agrees with the conclusion drawn from other evidence, that eels spawn in autumn or winter, and serves to determine the actual fact that some eels are on the point of spawning at the end of September and beginning of January. The equally important question of the place of their capture has next to be considered. Mr. Buckeridge, who very kindly answered the enquiries I made to him on the matter, told me that both specimens were found among consignments of eels from Toom Bridge, in Ireland. Now Toom Bridge is at the point where the river Bann leaves Lough Neagh, and is about 26 geographical miles from the sea. It is certainly an extraordinary fact that an eel so near the ripe condition should be found in fresh-water. We can only suppose that the case is exceptional. There is a possibility that the specimen had been kept in captivity for some time after being caught, and that thus its ovaries had had time to develop. But, on the other hand, when eels have been kept in salt-water aquaria, as they have been at the Plymouth Laboratory, in order that ripe specimens might be obtained, the ovaries have not developed to any obvious degree.

Rathke's specimen is described in *Müller's Archiv. für Anat. Physiol. &c.* 1850. It was brought to him, presumably in Berlin, by a fisherman on May 24th. It was dead, but in fresh condition. Nothing is stated concerning its place of capture. The ovary was 1½ in. wide in its middle part. The fat, which in ordinary eels is abundant between the eggs, was almost entirely absent. The importance of the condition of this specimen to Rathke's mind was the evidence it supplied that the eel was oviparous, and not viviparous.

It would appear that in addition to Rathke's specimen and the two here described, only one other nearly ripe female eel has been recorded. This fourth specimen is that mentioned by Calderwood, in a note in the *Ann. and Mag. Nat. Hist.* (6), vol. xii. 1893. But the description given is very scanty. The specimen was 29½ in. long, and was captured on December 27, 12 miles south of the Eddystone Lighthouse, or 20 miles from Rame Head, the nearest point of land. The width of the ovary and the size of the eggs are not mentioned. All that is stated is that the ovaries corresponded exactly in appearance with those figured and described by Brock in 1881, but Brock did not mention a ripe specimen. The ova are said to have been apparently ready to drop from the surface of the ovary, and to have been richly stored with oil globules.

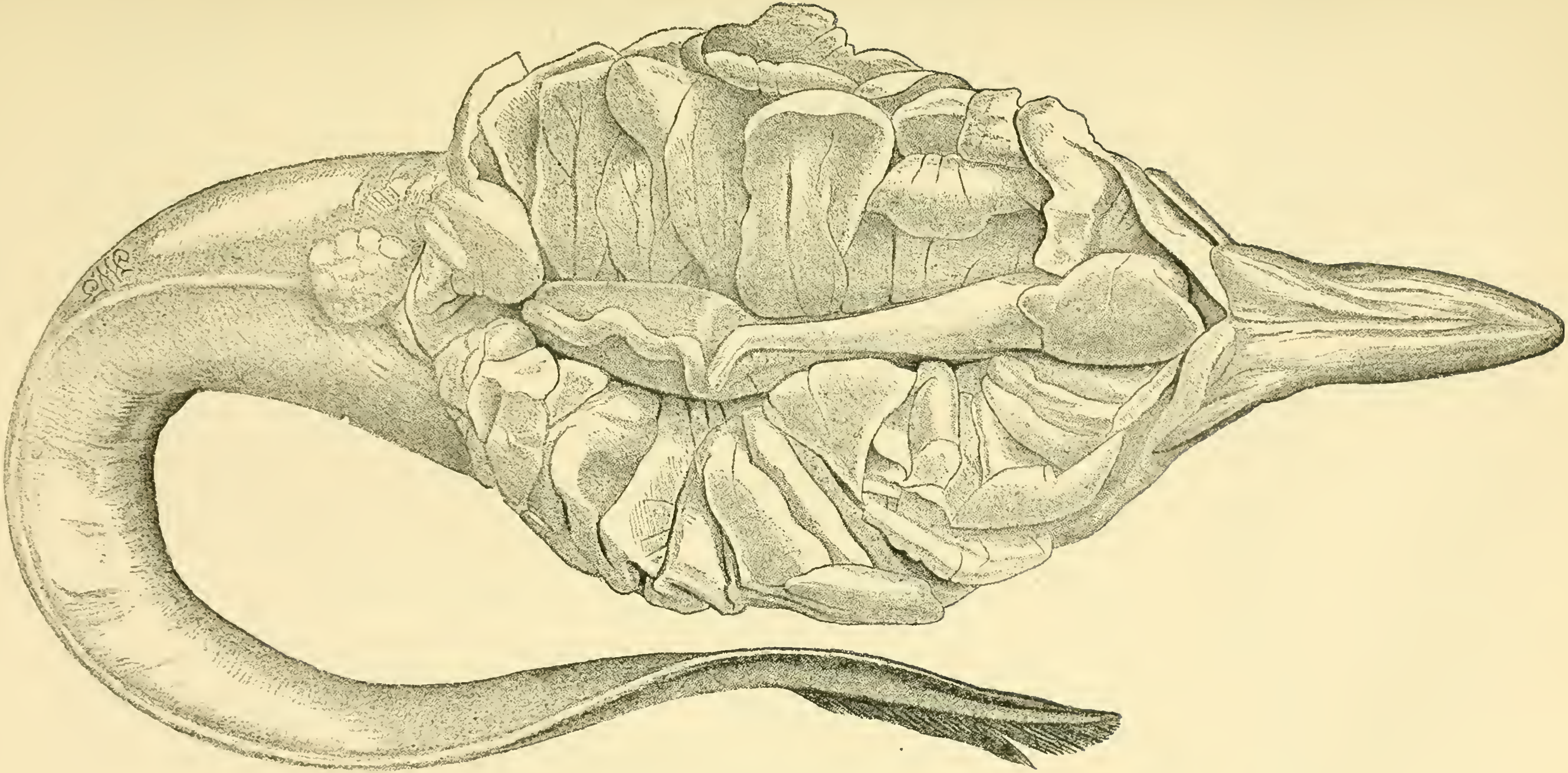


Fig. 1.—Female eel, with ovaries much enlarged and nearly ripe. (From specimen in the Royal College of Surgeons' Museum.)

Preliminary Note on Trawling Experiments in certain Bays on the South Coast of Devon.

By

F. B. Stead, B.A., Scholar of King's College, Cambridge,
Assistant Naturalist on the Staff of the Marine Biological Association.

THE following pages are intended to be preliminary to a fuller report which I shall hope to publish later on. For the present I shall confine myself to an account of the objects in view of which these investigations were begun, and of the method by which they have so far been carried out. I further propose to append a brief summary of some of the facts ascertained, reserving a more detailed statement for a future occasion.

The expectations with which the work was begun were twofold. It was hoped that by carrying out systematic experiments at fairly regular intervals, in certain well-defined areas within territorial limits, the characters of the populations of fishes of different species inhabiting these areas might be ascertained; and, further, that by selecting, for the purposes of the investigation, certain bays at present closed to trawlers, in accordance with a bye-law of the Devon Sea Fisheries Committee, the effects of a discontinuance of trawling within these areas might be experimentally tested.

This last expectation has, however, been disappointed, owing to the frequent infringement of the bye-law in question.*

The scientific issues of an investigation of this kind will become clearer as time goes on: its practical bearings were sufficiently obvious at the outset. For clearly it will afford evidence of a valuable kind in connection with any question that may be raised as to the advisability, or otherwise, of closing the bays investigated.

Investigations of a somewhat similar nature have already been carried out by the scientific staff of the Scotch Fishery Board for the east coast of Scotland, and by Holt for the west coast of Ireland. A comparison of the results obtained by me with those obtained for the above-mentioned districts, will be held over until my own results are more complete. But I may perhaps take occasion to point out that my object is not so much to arrive at conclusions, as to the general distribution of fish of different species and of different sizes, as to acquire a more exact knowledge of the changes which take place in the populations inhabiting particular areas.

---

* To what extent such illegal fishing has gone on, I am not in the position to say. But that it would be impossible to draw scientific conclusions as to the effect of closing the bays when the bays have not, in fact, been closed, is sufficiently obvious.

The areas selected in the first instance were Start Bay, Tor Bay, and Teignmouth Bay; and the 24-ton smack *Thistle*, of Brixham, carrying a trawl with a 40 ft. beam, was hired by the Association for the purposes of the investigation. I desire to take this opportunity of thanking the skipper and crew of this vessel for the willingness they showed in carrying out my wishes. At the same time, it may not be superfluous to point out that in undertaking work of this kind the Association is very seriously hampered by the want of a suitable steamer. Much time is necessarily lost on a sailing-vessel, even under favourable conditions, and calm weather may stop work entirely. Further, the necessity of making special arrangements as to hiring, and the delay that this entails, renders it impossible to make use of short spells of favourable weather. Moreover, the lack of accommodation on board a small smack puts any but the most cursory examination of specimens while on board entirely out of the question. In fact, it is not too much to say that the work might have been done with half the expenditure of time, and with far greater completeness, if the Association had had a steamer of its own.

So far, I have made two separate trips to the above-mentioned bays. On each occasion I was accompanied by the Association's fisherman, H. Roach.

The first of these trips lasted five days, from October 28th to November 1st; on the second, bad weather rendered all further work impossible at the end of the third day—December 4th.

The mode of procedure was as follows:—The times of shooting and hauling the trawl, the direction of the wind, the set of the tide, the depths in fathoms and the exact position of the vessel at the beginning and end of a shot, were all recorded. Notes were made of the "rubbish" that was brought up in the trawl; and, lastly, all the food-fish caught were measured to the nearest quarter of an inch. The measurements were, in all cases, made from the end of the snout to the tip of the tail.

Hauls were taken both by night and by day; and my efforts were directed, on the first trip, to obtaining fair samples of the populations of the several bays, and, on the second, to conducting operations in such a way that the successive hauls obtained in December might fairly be compared with those obtained in the same bays a month before.

It is not, of course, pretended that the same conditions, with the single exception of the difference in time, prevailed for corresponding hauls in two trips. When the physical circumstances are so complex and so variable, no such identity of conditions can be realised; and, in the absence of a scientific theory of trawling, it is quite impossible to appreciate, except in the roughest manner, in what way an observed difference in the physical conditions may be expected to affect the catch. All I would venture to claim is that, so far as it is possible to do this on a sailing boat, the same ground was towed over on the second trip as on the first, and that, further, when the physical conditions were manifestly unfavourable, and the catch was, in consequence, small, the facts were recognised, and the value of the evidence afforded by the catch in question was duly discounted. Thus, in summing up the statistics so far obtained for Start Bay, I have omitted to include the measurements of the fishes caught in the first two hauls—when, owing to the light winds and calm weather that then prevailed, the catches were relatively small, and the practical experience of the skipper informed me that we had not had "a fair trial."

Of the three bays selected for investigation, no adequate examination of one—Tor Bay—has, as yet, been made. Two hauls were made in this bay on November 1st. On each occasion the net came up filled with sea-weed—which had drifted into the bay owing to the rough weather that then prevailed outside—and with little else. On the second trip, which was cut short by a change in the weather, no trial could be made in this bay; nor has any opportunity since been given me of doing what was previously left undone.

Before proceeding to state the results thus far obtained for Start and Teignmouth Bays, I may make mention of the fact that it was originally my intention to make a certain number of hauls in the deeper water of twenty fathoms and more, outside the limits within which trawling is forbidden. Once more my constant enemy, the weather, has prevented more than one such haul being made; but the results of this haul deserve to be recorded.

The trawl was shot 3½ miles from Berry Head, which bore N.N.W., at 7.30 a.m., on December 3rd, at a depth of 21 fathoms, and was hauled at 11.30 a.m. from a depth of 18 fathoms—after being towed over a distance of about 3 miles in a straight line. The conditions as to wind, &c., under which the haul was taken, appeared to be favourable, and a remark to that effect was made to me by the skipper before the net was hauled.

The total catch consisted of 157 whiting, whose middle length* was

---

* By the "middle," or "mid" length, I mean the length on either side of which half the fish measured were found to lie.

10¼ inches; 55 dabs, with a middle length of 9 inches; 18 pouting, all under 7 inches; 7 grey gurnards, with a middle length of 10¾ inches; 1 tub, of 11½ inches; 1 turbot, of 19 inches; and only 5 plaice, respectively 10¼, 11½, 12, 12¼, and 12½ inches in length. It will be seen that the quantity of saleable fish in this haul, which lasted four hours, under conditions apparently favourable, was extraordinarily small. Too much importance must not, of course, be attached to the results obtained by a single haul; but I have given the facts as they stand, because, so far as they go, they tend to corroborate the statements again and again made to me by the fishermen. For it is alleged by these men, firstly, that, at this time of year, the fish are plentiful "in the bays"; and, secondly, that they are present in relatively small numbers "outside," though good catches may be made by the large smacks which can venture far out to sea. It is this, then, that constitutes the grievance, of which one result is that trawling can scarcely be said to have entirely ceased in the nominally closed areas. It would be premature, in this preliminary report, to offer any opinion on the much-debated question of the wisdom, or otherwise, of the legislation now in force; but it may perhaps be as well to point out that, assuming the statements above mentioned to be correct, they do not, in themselves, furnish an argument against the closure of the bays.

Setting aside, then, a consideration of the entire question till a future occasion, I may now pass on to a brief statement of the facts ascertained by trawling in the bays. In what follows no attempt is made to distinguish between the hauls taken on the first and those on the second trips; still less between the individual hauls in the same bays on either occasion. All that I have done is to add together the numbers of each species of food-fish caught in all the hauls considered in each bay, giving, at the same time, the middle length in each case. The results are tabulated below:—

	START BAY (3 HAULS).		TEIGNMOUTH BAY (4 HAULS).	
	TOTAL NUMBER CAUGHT.	MID LENGTH.	TOTAL NUMBER CAUGHT.	MID LENGTH.
Plaice	559	12½ in.	1088	10½ in.
Dab	890	8½ in.	511	7½ in.
Common Sole	35	11 in.	8	12¾ in.
Merry Sole	—	—	4	12 in.
Turbot	1	15¼ in.	2	13 in.
Brill	2	11⅞ in.	2	11 in.
Whiting	144	10⅝ in.	61	6 in.
Pouting	4	5 in.	40	6½ in.
Cod	1	20½ in.	—	—
Grey Gurnard	57	11⅜ in.	2	9⅛ in.
Tub	8	11⅞ in.	—	—
John Dory	11	11 in.	—	—
Herring	1	9 in.	—	—

An inspection of the above table will show that of the different species captured, plaice and dabs occurred in far the largest numbers. With regard to the relative numbers in which these two species were present in the bays, the table gives no certain information; for the proportionate numbers of plaice to dabs in the several hauls varied very considerably, and the number of hauls made was too few to make it possible for any conclusion to be drawn. It should, however, be noted that of these two species the plaice are alone important from an economic point of view, since the large number of competing dabs ought probably to be regarded as a positive hindrance to the well-being of the plaice; and that, therefore, any discussion as to the merits or demerits of the present bye-law should be almost wholly occupied with the question whether the closure of the bays to trawlers is necessary *for the protection of the plaice.*

It will further be observed that the plaice in the two bays differed from one another in respect of size; that while half the plaice caught in Start Bay were under 12½ inches, in Teignmouth Bay the mid-length was only 10½ inches. A similar difference obtains in the case of the dabs, whose mid-length was 8½ inches in Start Bay, and 7½ inches in Teignmouth Bay. These differences are of considerable importance; they appeared in a marked manner in all the hauls taken on either trip, and they imply a striking difference in character between the two bays.

Of these differences two explanations alone appear to me to be possible. They may be due in each case (1) to a difference in the ages of the fish caught in the two bays; (2) to a difference in their rate of growth.* As for the first of these explanations, it is difficult to see why there should be a larger proportion of older fish in Start Bay than in Teignmouth Bay; and with regard to the second, I am unable to point to any causes to which a difference in the rate of growth might be ascribed. Whichever explanation is adopted, a striking difference between the two bays, in respect of the most important fish they contain, appears to be indicated—a difference which is the more remarkable in that the bays in question are not more than 15 miles apart, and open into the same sea. Whether such a difference is constant throughout the year I am not yet in a position to say; but that it held good from October to December of this year there is no reason to doubt. Further, though it would be out of place in this preliminary paper to enter into further details, I may, perhaps, add that while the differences in the *mid-lengths* of plaice and dabs for these bays are the most obvious, they are not the *only* differences which appear, when the statistics are examined. The general impression which such an examination has so far given me is that each bay has a certain individuality of its own in respect of the populations it contains.

---

* The possible influence of differences in the depths at which hauls were taken in the two bays has not been overlooked; but a comparison of the soundings taken does not appear to favour such an explanation of the differences between their respective populations.

While plaice and dabs appeared in every haul in considerable numbers, the other species captured were obtained in relatively small numbers, and, in most cases, not in every haul. Thus the 144 whiting recorded for Start Bay were all obtained in the two hauls made in that bay on December 4th; while of the 57 grey gurnards, 29 were obtained on the first trip, and 28 on the second; and of the 35 soles, 33 were taken in the first haul made in Start Bay, and only two in the two last hauls.

Hence, for the present, at least, in attempting any comparison of the population of the bays examined, little account can be taken of the species captured other than plaice and dabs.

A careful comparison of the corresponding hauls in each bay has led me to believe that the attempt to obtain a fair idea of what a vessel provided with a similar net might be expected on the average to catch, was attended with success. And if we were only concerned with the practical and economic side of this investigation, this is all we should have to consider. As it is, the further question arises, How far do the catches so obtained represent the actual populations of the bays? It must be admitted at once that the results are *incomplete*, since they do not apply to the shallower portions of these bays, with depths of less than 5 fathoms. I intend, therefore, to supplement the facts ascertained by trawling, by an investigation into the catches of the inshore fishermen. It remains to consider to what extent the results are imperfect, for those portions of the bays to which they do apply. That the width of mesh of the net employed exerts some selective influence, in permitting the escape of small fish, seems tolerably certain. But in the case of the plaice, at least, there is good reason to think that this factor did not operate to any serious extent. Dr. Fulton's investigations* have shown that with an ordinary net of 1½-inch mesh from knot to knot, out of a total number of 1080 plaice under 8 inches, only 58 escaped (*i.e.* 5·3 per cent). In my own investigations, the total number of plaice captured under 8 inches in length is only 71. Unless, then, the proportion of the plaice that escaped was far larger in these experiments than in those carried on by the *Garland*, the selective influence of the net, in permitting the escape of small plaice, may be neglected.

The same cannot, however, be said for dabs. For these fish, Fulton's results show "that with an ordinary net of 1½-inch mesh, the great majority of the specimens at or below 6 inches escape."

---

* *Twelfth Annual Report of Scotch Fishery Board*, iii. p. 307.

It must further be remembered that other factors may come in—of which we know little or nothing—tending to create a discrepancy between the apparent results as ascertained by trawling, and the actual populations existing in the bays. But this fact, while it should make us cautious in drawing inferences from the former to the latter, does not invalidate any comparison we may institute between the results obtained under like conditions in the two bays.

It would be unwise at this juncture to attempt in any way to forecast the results to which these investigations may lead us. But apart from the practical object in view of which they were begun, there are at least three subjects on which these experiments, if systematically carried on, ought to throw light: (1) the rate of growth of the more important fishes captured; (2) the migrations which may take place from the areas in question for the purposes of spawning, or from other causes; (3) the nature and influence of local conditions as affecting variations. To what extent it may be possible to attain these ends is uncertain; but that the method of this investigation—consisting, as it does, in an attempt to study the characteristic features of particular localities—is a sound one, I have become more and more convinced as the time has gone on.

North Sea Investigations.

(CONTINUED.)

By

J. T. Cunningham, M.A.

PAGE

I. The Size of mature Plaice, Turbot, and Brill, on different Fishing Grounds 97

II. Observations at Sea and in the Markets:—

  1. Grimsby 108

  2. Scarborough 112

  3. Hull—The Adoption of the Otter Trawl in Steam Trawling . 114

  4. Lowestoft 121

III. Causes of the Observed Distribution of Fish in the North Sea . . 133

IV. Proposed Restrictions on the Landing of Undersized Plaice in the light of the New Evidence 138

I. THE SIZE OF MATURE PLAICE, TURBOT, AND BRILL, ON DIFFERENT FISHING GROUNDS.

In the previous number of the Journal, I described my reasons for doubting whether the conclusions drawn by Mr. Holt, concerning the size at which plaice become mature, would hold good for the whole of the North Sea; and also whether the evidence he relied upon, in distinguishing mature and immature plaice, was sufficient. I stated that, as an actual fact, one sample of mature plaice, which were much below the limits of size determined by Mr. Holt, had come into my hands. I suggested, as a probability, that the presence of dead degenerating eggs in the tissue of the ovary was a proof that the fish had spawned, was a spent, and therefore a mature specimen. My words were: "It cannot be asserted as a certainty that these granular masses never occur in an immature ovary; to settle the doubt it will be necessary to make a careful examination of plaice in November and December, when all fish which are about to spawn will have a large amount of yolk in the eggs, and all fish in which the eggs are transparent and yolkless must be immature." It was already known that these degenerating eggs do occur in spent ovaries, from which the ripe eggs have recently been discharged, and which bear evidence of the fact in their somewhat large size, flaccid and collapsed condition, and usually in the presence of a few detached ripe eggs in their interior. Observers were agreed that the explanation of this fact was that when spawning was finished, a certain number of eggs were still only partly developed, and that these, instead of completing their development, degenerated, and were gradually removed by absorption in their place without being discharged. It seemed natural to infer, therefore, that in every ovary in which microscopic examination showed the presence of these degenerating eggs, spawning had previously occurred.

This supposition has proved, however, to be incorrect. The granular opaque masses have been found in the ovaries of the plaice in every month of the year from February to December, and in November and December have been found to occur nearly always in ovaries, which showed no trace of the development of yolk in the healthy eggs, which were, therefore, undoubtedly immature, the mature ovaries at this time being much enlarged and far-advanced in development. At this time no fish had begun to spawn, and none were in the spent condition. It is clear, then, that aborted partially yolked eggs do occur in immature ovaries. In different specimens these aborted eggs are seen in different stages of degeneration, and it is evident that in an immature ovary a small number of eggs are constantly beginning to develop yolk, as though about to become ripe eggs, but almost immediately die and degenerate instead of continuing their development. The same process is going on in mature ovaries between the spawning seasons. When the fish becomes mature, then some months before the spawning season a large number of eggs continue to develop without check or interruption until the crop of ripe eggs is produced.

The plaice which, on February 27 last, I found to be mature at sizes below Mr. Holt's limits, were said to have been caught off the Leman Shoal, at a depth of 12 to 17 fathoms. I do not feel sure that this was really their place of capture, for reasons which will appear in the sequel. But I have found that the plaice, taken by the Lowestoft trawlers in the neighbourhood of the Brown Ridges, are certainly mature at sizes similar to those which characterise the sample mentioned, and considerably below Mr. Holt's limits. On October 2nd, I made a complete examination at Lowestoft of a box of plaice from the Brown Ridges. As it was so considerable a time before the commencement of the spawning season, I did not attempt to distinguish between mature and immature males. But in many of the females yolk-formation had distinctly commenced, or was even somewhat advanced, and these I put down as mature, the others as immature. The results are as shown in the following table:—

Box of Plaice from Brown Ridges, October 2nd, 1895.
Total number, 176.

Length in inches.	Males.	Females.		Totals.
		Mature.	Immature.	
9	1	1 ($9\frac{3}{4}$ in.)	2	4
10	6	—	12	18
11	25	6	24	55
12	27	12	24	63
13	10	14	5	29
14	2	1	—	3
15	—	—	—	—
16	—	3	—	3
17	—	—	—	—
18	—	—	—	—
19	—	1	—	1
	71	38	67	176
	(40·3 per cent.)	(21·6 per cent.)	(38·1 per cent.)	

On November 18, I examined another sample, sent from Lowestoft to me in London. The information given me, concerning the place of capture, was that it was on the track of the Harwich boats, nearer the Dutch than the English coast. This would be somewhere to the west of the Hook of Holland. The condition of these plaice was as shown in the following table:—

Plaice from Lowestoft, November 18th, 1895.
Total number, 197.

Length in inches.	Males.		Females.		Totals.
	Mature.	Immature.	Mature.	Immature.	
8	—	1	—	—	1
9	6	9	—	4	19
10	17	14	2	21	54
11	21	7	12	27	67
12	17	4	11	9	41
13	4	—	5	1	10
14	1	—	1	—	2
15	1	—	—	—	1
16	—	—	1	—	1
17	—	—	—	—	—
18	—	—	1	—	1
	67	35	33	62	197
	(34 per cent.)	(17·8 per cent.)	(16·7 per cent.)	(31·5 per cent.)	

It is possible that, in this last sample, some of the males set down as immature would have become mature before the end of the spawning season, but this is not a question of great importance. In both samples the limits of maturity and immaturity in the females agree with those seen in the sample examined at Grimsby: these limits are 9 in. and 14 in. Below 9 in. no females are mature, above 14 in. none immature. The limits at Plymouth were almost exactly the same, except that three specimens were found to be immature at 14 in. Mr. Holt's limits, on the other hand, were 13 in. and 18 in., so that there is a difference of 4 in. between both the upper and lower limits in the two cases. There is every reason to believe that the maximum size actually attained by the fish corresponds to the size at which it begins to spawn. As a matter of observation we find that the largest plaice caught in the neighbourhood of the Brown Ridges are considerably smaller than the largest caught on grounds further to the north. The largest plaice in the samples above described does not exceed 20 in. in length.

The ground named extends between thirty and fifty miles from the Dutch Coast, and to a great distance in a north and south direction. It is limited by the "edge of the deep water" towards the English coast, and this boundary (the twenty fathom line) lies at about fifty-five miles from the coast of Norfolk. The ground is undulating, being traversed by ridges running north and south, over which the depth decreases to a minimum of 11 fathoms, while, in the valleys between, there is, in some places, a depth of 24 fathoms. The ground is therefore neither uniformly shallow, nor close to the land.

I was strongly inclined to think that the small plaice of the German Bight would prove to be of the same character as those from the Brown Ridges. My theory was that the race of smaller plaice actually proved to exist off the coast of Holland would be found to extend along the Dutch and German coasts, probably as far as the Horn Reef, and that this would be the explanation of the small size of the plaice landed at Hull and Grimsby, from the German or Heligoland Bight. In order to examine samples of the plaice caught on these eastern grounds in November and December, I considered whether it would be advisable to go to the Biological Station of Heligoland, or to some fishing port on the German coast, or to have samples sent over the sea to me in London. I made enquiries from Dr. Heincke, the Director, and Dr. Ehrenbaum, the Zoologist of the Biological Station, and have much pleasure in here expressing my thanks for the courtesy and thorough efficiency with which they assisted me to obtain the facilities I required. They informed me that plaice were not landed in Heligoland regularly or in large numbers, but that they would assist me in my undertaking if I visited one of the fishing ports on the mainland. I thought, however, that, under the circumstances, I might just as well have samples sent to me in London, and accordingly Dr. Ehrenbaum put me in communication with Herr Düge, the harbour-master at Geestemünde, who undertook to forward me samples of plaice, with most careful attention to all the precautions and conditions I required. The first sample reached me on November 20th, and the following table shows the result of their examination :—

PLAICE FROM GEESTEMÜNDE, NOVEMBER 20TH, 1895.

Total number, 186.

	Males.		Females.		
In.	Mature.	Immature.	Mature.	Immature.	Total.
10	—	5	—	2	7
11	2	43	1	35	81
12	7	27	—	36	70
13	1	3	—	17	21
14	—	—	—	2	2
15	—	—	—	—	—
16	1	—	—	—	1
17	1	—	—	—	1
18	—	—	1	—	1
19	—	—	—	—	—
20	—	—	2	—	2
	12	78	4	92	186
	(6·5 per cent.)	(41·9 per cent.)	(2·1 per cent.)	(49·5 per cent.)	

It will be seen, at once, what a striking contrast these fish present to those from the grounds south of the Texel. The single mature specimen at 11 in. is of no importance in comparison with the large numbers of immature. We may say that all below 15 in. were immature, so that they correspond very closely with the plaice examined by Mr. Holt, at Grimsby.

Among the males there are a larger proportion mature at 12 and 13 in. than Mr. Holt found, but in the females there is no evidence of maturity at a smaller size than that fixed by him. We must conclude, then, that these fish are small because they are young and immature, not because they are of a smaller race. These fish were stated by Herr Düge to have been caught at 53° 58′ north latitude and 7° 10′ east longitude from Greenwich, a position about 15 miles north of the island of Nordeney, at a depth of 13 to 14 fathoms.

In a letter which I received on December 5th, Herr Düge informed me that among the plaice landed at Geestemünde, he found the smallest ripe males were 32 cm. long ($12\frac{4}{5}$ in.), the smallest mature females 40 cm. (16 in.), an observation which agrees with the results of my examination of the German plaice in London.

The above sample does not afford complete evidence concerning the range of size, or the proportional numbers at different sizes, of the plaice taken on the ground from which it came, because it consists, as Herr

Düge informed me, of the marketable fish selected from the whole number brought up by the trawl, the smaller being rejected. This, of course, makes no difference with regard to the minimum size of mature specimens; all those rejected less than 10 in. in length must have been immature. The smaller fish, which were thrown overboard, however, when the sample was taken, were stated to be very few in number, although Herr Düge tells me that it sometimes happens, even in winter, that, in the same locality, plaice mostly from 9 to 12 in. in length are taken.

I was desirous of obtaining a sample sent, without selection, just as they came on deck, and Herr Düge was good enough to send me a second consignment. These fish were trawled on December 20th, in 54° 35′ north latitude, 7° 40′ east longitude, at a depth of 11 fathoms. This position is about 24 miles from the Amrum Light, and in the very same neighbourhood in which the steam trawler, *John Bull*, was fishing, in June, when I was on board her. The sizes and conditions of these fish are shewn below:—

PLAICE FROM GEESTEMÜNDE, DECEMBER 20TH, 1895.

Total number, 121.

	Males.		Females.		
In.	Mature.	Immature.	Mature.	Immature.	Total.
9	—	1	—	—	1
10	—	4	—	1	5
11	—	5	—	6	11
12	—	7	—	17	24
13	2	8	—	35	45
14	3	3	—	13	19
15	—	1	1	7	9
16	—	—	—	4	4
17	—	—	1	—	1
18	1	—	—	—	1
19	—	—	1	—	1
	6	29	3	83	121
	(4·9 per cent.)	(24 per cent.)	(2·5 per cent.)	(68·6 per cent.)	

It will be seen that these unselected plaice were, on the whole, not smaller, but somewhat larger than those in the previous sample from German waters, and with the quite insignificant exception of the one specimen at 9 inches, did not include any smaller specimens. With regard to immaturity, the second sample agrees with the first, no less than 92·6 per cent. of the whole number being immature. In both samples the proportion of mature female specimens below 18 inches is even distinctly lower than in Mr. Holt's records taken at Grimsby.

A comparison between these plaice, caught off the German coast in November and December, and those which I have described in the previous number of the Journal, as caught under my own observation in June, in the same neighbourhood, is worthy of careful attention. Firstly, with regard to the locality of capture. The position given by Herr Düge, for the second sample, is 24 miles west of Amrum Light; and in the cruise of the *John Bull,* the Amrum Light was seen, on two nights, at a distance of 20 miles. Thus, the *John Bull* was fishing on these occasions 4 miles nearer the land, and it is true that sometimes she was steered nearer the land than this; but she was also fishing sometimes out of sight of the Amrum Light, and the ground she covered must have included the position where the December sample was taken. Next, with regard to the depth: during the fishing of the *John Bull,* it varied from 7½ to 12½ fathoms, while the December sample was taken at 11 fathoms. At the seventh haul in the record of the trip of the *John Bull* the depth was 12 fathoms, and at this haul a number of plaice, 7½ to 10 inches long, were taken, two baskets 10 to 12 inches long, and two baskets 12 to 15 inches long. The comparison shows, therefore, that although the *John Bull* extended her operations to positions nearer the land than that where the December sample was taken, yet it is clear that she also fished at the same depth and distance from land, and obtained there numbers of plaice of small sizes, which are not represented in that sample. On the other hand, the December sample includes specimens larger than any taken on the same ground in June, when the maximum was 16¾ inches. It appears to me quite probable that these differences are due simply to the growth of the fish in the six months' interval. We must either conclude that the fish taken on the German grounds in early summer are of the same race as those taken in December, and therefore, with the exception of a small minority, principally males, immature; or we must suppose that they are fish of a smaller race which migrate to these grounds from some other, *e.g.*, more southern region. This latter supposition is at present unsupported by any evidence, and I think we must seek to explain the facts on the view that the summer and winter fish are of the same race. This is not difficult, if we suppose that the smaller fish—6 to 10 inches long—are the year-old fish, which move out from the shallow inshore waters on to those grounds at the beginning of their second summer. The larger immature fish, broadly speaking, from 10 to 15 inches long, must be two-year-old fish, while the number of mature fish over three years is in small proportion. The dispersal of the year-old fish to greater distances from land, and their gradual increase in size, would account for the fact that the fish on the Eastern Grounds become both much less numerous, and generally larger in late summer and autumn.

I have found that the condition of the plaice along the English coasts of Norfolk and Suffolk is not the same as along the opposite Dutch coast. It would appear that the Channel conditions extend northwards along the Dutch coast, while the size of the mature plaice, which is characteristic of more northern grounds, extends southwards to some distance along the English coast. Some of the Lowestoft smacks were fishing in October, near the Leman Shoal, and on neighbouring grounds, and were landing plaice considerably larger than those from the Brown Ridges. I examined a box of these large plaice on October 4th, in the same week in which I examined the sample from the Brown Ridges. The results were as follows:—

PLAICE FROM LEMAN SHOAL, OCTOBER 4TH, 1895.
Total number, 115.

Length in inches.	Males.	Females. Mature.	Females. Immature.	Totals.
9	1	—	—	1
10	5	—	4	9
11	15	—	6	21
12	6	1 (12⅞ in.)	9	16
13	14	—	7	21
14	7	5	5	17
15	4	8	1	13
16	—	6	2	8
17	—	5	—	5
18	—	3	—	3
19	—	—	—	—
20	—	—	—	—
25	—	1	—	1
	52	29	34	115
	(45·2 per cent.)	(25·2 per cent.)	(29·6 per cent.)	

The Leman Shoal is somewhat further north than the Brown Ridges, being in the same latitude as the island of Texel, and the depth in its neighbourhood does not exceed 20 fathoms. The contrast between these plaice and those from the Brown Ridges is very marked. It will be seen that the proportion of mature females among the former is not much greater, 25·2 per cent., as compared with 21·5 per cent. of those from the Brown Ridges. If we take the females separately, the proportion of mature individuals among these is certainly higher in the sample from the Leman Shoal, *i.e.* the sample of larger fish: it is 46 per cent. among these, 36·1 per cent. among the fish from the Brown Ridges. But this is not a very great difference, and appears to be due chiefly to the fact that, in the one sample, there were more males and fewer immature females than in the other. The general difference in size in the two samples is sufficiently obvious from the fact that one box contained 176 fish, the other only 115, the box in both cases being of the same size. If we compare the limiting sizes of the mature and immature, they are 9 in. and 14 in. in the case of the smaller, 12 in. and 17 in. in that of the larger, a difference of 3 in. By limiting sizes, I mean the smallest mature and largest immature. Thus the relation of size to maturity in the Leman Shoal plaice agrees closely with that observed by Mr. Holt at Grimsby.

I have endeavoured to obtain samples of plaice from the English side, further south than the Leman Shoal. Opposite the coasts of Norfolk and Suffolk there is a depression of the sea-bottom, ranging from 20 to 27 fathoms in depth, its eastern boundary being about midway between the English and Dutch coasts. I tried to obtain a sample taken in this deep water. The box that was sent to me from Lowestoft, in response to a request to this effect, was stated to have been taken 40 to 45 miles E.S.E. of Lowestoft, a position which would be near the eastern limit of the deep water.

The fish proved, on examination, to be much more immature than the samples from more eastern grounds already described, although, if the place of capture is correctly reported, it is only about 20 miles further from the Dutch coast than the Brown Ridges, where the smaller fish were taken. The sizes and condition were as here shown.

Plaice caught 40 to 45 miles E.S.E. of Lowestoft, Dec. 23rd, 1895.
Total number, 132.

	Males.		Females.		
In.	Mature.	Immature.	Mature.	Immature.	Totals.
9	—	1	—	2	3
10	—	9	—	7	16
11	9	9	—	9	27
12	8	5	1	23	37
13	6	4	1	14	25
14	—	1	—	7	8
15	2	—	1	1	4
16	5	—	2	—	7
17	—	—	3	—	3
18	—	—	2	—	2
	30	29	10	63	132
	(22·7 per cent.)	(22 per cent.)	(7·5 per cent.)	(47·8 per cent.)	

This sample is intermediate in its limiting sizes between the Dutch plaice and the more northern plaice, the limits being 12 in. and 16 in. for females.

In order to make a direct comparison between the samples already mentioned with one from more northern grounds, I obtained a box from Billingsgate. Mr. Richard Vivian, agent of the Hull Steam Fishing and Ice Co., kindly undertook to send me a box, with reliable information concerning the ground on which the fish were taken, and was in a position to obtain this information from the master of the steam carrier which brought the fish from the fishing fleet to London. Accordingly I received, on December 6th, a box of plaice which had been trawled on the south side of the Dogger Bank, in 55° 20′ north latitude, 4° 30′ east longitude, at a depth of 24 fathoms.

The following is the record of the sizes and condition in this sample:—

PLAICE FROM SOUTH SIDE OF NORTH-EASTERN PORTION OF THE DOGGER BANK, 24 FATHOMS, DECEMBER 6TH, 1895.

Total number, 68.

	Males.		Females.		
In.	Mature.	Immature.	Mature.	Immature.	Totals.
10	—	4	—	2	6
11	—	4	—	8	12
12	1	3	—	2	6
13	—	7	—	3	10
14	2	1	—	6	9
15	3	1	—	4	8
16	9	—	1	1	11
17	1	—	1	1	3
18	—	—	—	—	—
20	—	—	—	—	—
21	—	—	2	—	2
23	—	—	1	—	1
	16	20	5	27	68
	(23·5 per cent.)	(29·4 per cent.)	(7·4 per cent.)	(39·7 per cent.)	

The upper limit of the immature here is as high as in Mr. Holt's results; the lower limit of the mature is unusually high. The reason of the latter fact is to be found in the small number of specimens at each size in the sample. Mr. Vivian informed me that the plaice were packed in two sets, some boxes containing only large fish, others containing mixed sizes. My sample was one of the latter. We cannot, therefore, look upon this sample as representing the general condition of the plaice caught on the ground from which it came, but it is important to notice that considerable numbers of plaice from 10 in. to 13 in. long, and quite immature, are caught right in the middle of the North Sea, about 150 miles from the coast either on the east or west.

The sizes and conditions of the turbot and brill which I examined in May and June last year, are shown in the two tables here given. Most of them were examined on board the two trawlers on which I made the two voyages described in the previous number of the Journal; but in addition are included 20 brill from the same grounds, which I examined on shore. Some smaller specimens, which were only 8 and 9 in. long, were measured, but their sex not ascertained.

TURBOT ON THE GERMAN GROUNDS, SOUTH OF HORN REEF, AND OFF AMRUM, 7 TO 15 FATHOMS, MAY AND JUNE, 1895.

	Males.		Females.	
In.	Mature.	Immature.	Mature.	Immature.
11	1	—	—	1
12	1	—	—	2
13	14	—	—	2
14	10	—	1	5
15	1	—	—	4
16	2	—	—	—
17	—	—	—	—
18	—	—	—	—
19	3	—	—	—
20	4	—	1	—
21	1	—	—	—
22	—	—	2	—
23	—	—	—	—
24	—	—	2	—
25	—	—	1	—
26	—	—	—	—
27	—	—	1	—
28	—	—	1	—
29	—	—	3	—
30	—	—	—	—
31	—	—	1	—

BRILL ON THE GERMAN GROUNDS, SOUTH OF HORN REEF, AND OFF AMRUM, 7 TO 15 FATHOMS, MAY AND JUNE, 1895.

	Males.		Females.	
In.	Mature.	Immature.	Mature.	Immature.
10	4	—	—	2
11	3	5 ?	—	16
12	1	2 ?	—	23
13	—	—	1	8
14	1	—	1	3
15	—	—	2	—
16	1	—	1	—
17	1	—	3	—
18	—	—	1	—
19	—	—	—	—
20	—	—	1	—

II.—Observations at Sea and in the Markets.

1. *Grimsby.*

At Grimsby there are a number of trawlers—some steamers and some sailing vessels, which are locally called Cleethorpers, and regularly fish on the grounds near the Humber, returning to port at the end of the week. I went out in one of these, the s.s. *Rhine*, on July 22nd. My object was to examine the grounds near the mouth of the Humber and the Wash, in order to compare them with the grounds off the German coast. We shot the trawl at 2 p.m. the same day, having steamed 55 miles by the log from the Newsand Lightship, at a position a few miles west of the Coal Pit or N.E. Hole, as it is named on the chart illustrating Mr. Holt's description of the Grimsby Trawl Fishery. The depth during the haul was 13 to 18 fathoms. The temperature at the surface was 58° F.

The trawl was hauled up at 7.15 p.m. The scruff was plentiful, and consisted of Hydroids, chiefly *Sertularia* and *Hydrallmania. Alcyonidium*, called by the fishermen "curly cabbage," was also extremely abundant. Another Polyzoan, namely *Crisia*, was plentiful, and there were many *Solaster papposus*. The quantity of marketable fish was very small. The smallest plaice was 8¾ in. long, and there were 7 from this size to 10¾ in.; these were thrown overboard. Some lemon soles 8¾ to 9½ in., a few haddock of 8½ in., and some small dabs 6½ in., were also rejected. The fish packed away were:—1 basket plaice, ½ basket haddock, ¼ basket lemon soles and whiting, ½ basket dabs, with a few codling, 4 soles. There were also 10 roker, or rays, and 1 lobster, 10 in. long.

The next haul we steered N., down the Coal Pit, and sounded 22½ fathoms. The trawl was hauled at 11.30 p.m. The scruff again was very abundant, consisting chiefly of the *Alcyonidium;* Hydroids also were very plentiful. There were present also *Alcyonium*, compound Ascidians, and *Solaster papposus*. Among the Hydroids were large clusters of *Antennularia antennina*.

The smallest plaice was 8¼ in. long; smallest haddock 7¾ in.; smallest whiting 8¼ in.; smallest lemon sole 7¾ in., a female, immature.

There were 1 solenette 3¾ in., a mature female, and 2 others; 1 latchet, a small specimen; 1 scad (*Caranx trachurus*), 1 cod, and 2 rays. The other marketable fish were:—¾ basket plaice, ¼ basket haddock, ¼ basket dabs, ¼ basket lemon soles and whiting.

Third haul, also in Coal Pit, 11.45 p.m. to 5.0 a.m. on Tuesday. As before, a large quantity of scruff and a small quantity of fish. Besides the other items seen in the scruff before, there were several sea-urchins (*Echinus miliaris*). Of the fish, a basketful of small haddock, whiting, and dabs, and a few small gurnard, were thrown overboard; the small haddock measured 6¾ to 8¼ in., there being only 2 or 3 of marketable size. The smallest dab was 5 in., a male, the largest 14½ in., a female. The smallest plaice was 7½ in., a female, the largest 20½ in., but only 2 were small enough to be thrown overboard. The marketable fish were:—1 basket plaice, ¼ basket dabs, 6 rays, and 4 lemon soles.

Fourth haul, in the Sole Pit which lies to the N.W. of the Coal Pit, and has a maximum depth of 43 fathoms. We sounded 40 fathoms once, and afterwards 13½ fathoms. The trawl was hauled at 8.30 a.m. There was less scruff than before, but *Alcyonium*, or "teats," were very plentiful in it. Only a small quantity of fish. The smallest plaice was 10 in., an immature female; there were altogether 28 females, the largest 21½ in.; 19 males, the largest 20½ in. There were a few lemon soles, haddock, roker, cod, grey gurnard, and dabs. Up to this time we had not taken a turbot or brill.

Fifth haul, 11.30 a.m., June 23rd, to 4.30 p.m., along the east side of the Sole Pit. Scruff as usual, with the addition of whelk-spawn and *Flustra*, sometimes known to the fishermen as "scented weed."

The smallest plaice was 9½ in., and only one thrown over: largest 21¼ in. Some small haddocks 8½ in. Smallest lemon sole 8¼ in. The fish thrown away were ¼ basketful of small haddocks, whiting, gurnards, dabs, the haddocks up to 10½ in., dabs up to 9½ in., and all the grey gurnard. The fish kept were 1¼ baskets plaice, 1 basket kit haddock, ¼ basket dabs and codlings, ¼ basket whiting and lemon soles, 3 small roker (*Raia clavata*), and 2 turbot, one 22 in. male, ripe; one 2 ft. 1½ in. female, not ripe.

Fifteen more hauls were made in or close to the Sole Pit with varying fortune, but several of them were failures, in consequence of the trawl catching fast and the net being torn. The ground in this part is rough, and necessitates short hauls and much net mending. The scruff was always abundant and of much the same composition. I made a careful examination of all the waste fish from one haul. The marketable fish from this haul was:—1 basket plaice, 1½ baskets kit haddock, ½ basket dabs and codling, ½ basket lemon soles and whiting, 14 soles, 2 cod, 1 crab, 12 small rays.

The waste fish filled nearly a basket, and comprised:—220 dabs, 3¼ in. to 10 in. long; 86 haddock, 7 in. to 11 in. long, measured to the end of the middle ray of the tail; 46 grey gurnard, 6¾ in. to 11¼ in. long; 11 codling, 5¾ in. to 10½ in. long; 3 whiting, 9¼ in. to 10 in.; 8 plaice, 8¼ in. to 10 in.; 7 lemon soles, 7 in. to 10 in., the smallest a ripe male; 3 scad, 11½ in. to 12½ in.; 1 bib (*Gadus luscus*), 6¾ in.;

2 solenettes; 3 *Trachinus vipera*, the lesser weever; 2 thornback rays, 8 in. to 9½ in. across pectorals; 1 long rough dab, 9 in. long.

Plaice up to 24 in. and 26 in. in length occurred in these hauls, and as in the above instance only an insignificant number under 10 in., which were thrown overboard.

After this a haul was made 7 or 8 miles to the east of the Dowsing Lightship, at a depth of 9 to 11 fathoms. The marketable fish caught were:—1¼ baskets plaice, 1¼ baskets lemon soles, codling, and haddock mixed; 2 rays, 2 brill 23¾ in. long. The largest plaice was 24 in., and 4 plaice of 9 in. were thrown overboard.

There was an extraordinary quantity of *Alcyonidium*, or "curly cabbage," about 1½ basketfuls, the scruff consisting almost entirely of this. One horse mussel (*Mytilus modiolus*), and 2 sunstars were seen.

At the next haul the trawl was down 6 hours, from 9 p.m., July 26th, to 3 a.m., July 27th. A still greater quantity of *Alcyonidium* was brought up—3 or 4 basketfuls. The fish were:—2 baskets plaice, ¾ basket kit haddock, ¾ basket lemon soles and whiting, ½ basket dabs and codling, 14 soles, largest 18½ in., smallest 7 in.; 2 cod, 1 ray, 8 crabs.

A basket of plaice is rather more than half a boxful, as the boxes are packed for sale, and the number in a basketful may therefore be estimated at about 50 fish.

Only two short hauls of no importance were made after this on the same ground, and then we returned to Grimsby.

It will be seen that the grounds visited in this voyage were all too far from the English coast to be considered as corresponding to the grounds visited in the s.s. *John Bull*. The nearest of them is the Outer Dowsing Ground; the Outer Dowsing Light is 30 miles from the nearest coast, and we fished on the farther side of the Lightship. The depth off the Dowsing was scarcely greater than off the Island of Amrum. We sounded 11 fathoms, and, doubtless, trawled in shallower water than that. The other grounds are narrow gullies, surrounded by fairly level ground less than 20 fathoms in depth. In the character of the bottom, these grounds differ very greatly from those visited in both my voyages on the German side. The latter were nearly all sandy, and very little scruff was brought up: pieces of *Flustra foliacea*, and *truncata*, and *Hydrallmania* were entangled in the net, but the total bulk was inconsiderable. On the English Grounds, on the contrary, the quantity of scruff was enormous, and indicates a coarse varied ground of stones and shells.

With regard to the character of the fish, the grounds above described resemble those to the south of the Horn Reef Lights, a voyage to which was described by me in the previous number. That ground was farther seaward than the ground where the small plaice were taken; it was mostly from 24 to 30 miles from Blaavand Point, the nearest land, and the depth 11 to 15 fathoms. The plaice were in both voyages mostly between 12 and 26 inches in length, although about twice as abundant on the German side. The haddock, too, were abundant at the Horn Reef, scarce in the voyage of the *Rhine*, and most other kinds of fish were more abundant on the German Ground, but in the absence of small turbot and brill the two grounds agree. My expectation, therefore, of examining during the voyage of the *Rhine*, grounds which corresponded in their depth and distance from the Lincolnshire coast with the small plaice grounds to the north of Heligoland, was disappointed. Nor could I find other opportunities of making such an examination. I questioned some of the skippers of sailing smacks which fished the home grounds near the Humber, and was informed that they trawled chiefly in the Yorkshire Hole or Little Silver Pit, and the Westernmost Rough, grounds mostly about 20 miles from the coast. The plaice which I saw landed from these boats were small, but there was no great quantity of them, not more than one box from any one boat. Besides the plaice they had about 3 boxes of soles, 3 or 4 boxes of haddocks, and a few cod, lemon soles, and turbot. I bought a sample of the small plaice, and found there were 18 females 8½ in. to 12½ in. long; 19 males 8½ in. to 12¼ in. long.

The evidence is, therefore, still incomplete, but as far as it goes it does not support a supposition I had formed that large plaice 20 in. and upwards were found in shallower water, and nearer the land on the English coast than on the German. This supposition was suggested to me by the fact that whereas only small plaice were brought from certain grounds on the German side, I could not discover that there were any grounds off the Lincolnshire coast where only small plaice were caught. At present we have no proof, however, that the larger plaice are to be taken at depths of 7 to 12 fathoms on the Lincolnshire coast. The shallow grounds, close to that coast, are not so extensive as on the German side, and according to my experience the Grimsby trawlers usually find more profitable fishing in the deep gullies, to which there is nothing corresponding on the German coast, and in which large plaice are taken It may also be noticed that even in the voyage of the *John Bull* the small plaice became scarce as soon as the ship steamed to a somewhat greater distance from the land. Thus our course from the Spurn Lightship was E.½S., which would take us to a position S.E. of the Sylt Island: at our first haul the depth was 13 to 14 fathoms, and we got none of the small plaice, that is to say, none under about 12 inches. The captain said we were 18 or 20 miles west of the Sylt, but this was merely an approximate estimate, and we were probably somewhat farther out. Again, in the fourth haul, the vessel was steered away from the coast out to the depth of 12 to 13 fathoms, and small plaice were taken in insignificant numbers.

2. *Scarborough.*

I was at Scarborough from August 12th to August 21st, and during that time was not entirely occupied in the study of the fishing industry. Consequently I do not pretend to give a complete description of the fishing at this place. Scarborough did not present any features of sufficient importance to demand a long and close investigation.

The harbour is small, and situated in the angle between the south side of the Castle Rock and the shore of the bay, which runs towards the south-east. A large number of drift-net boats belonging to Lowestoft were fishing out of Scarborough, and landing their catches there, but they did not use the harbour much, anchoring for the most part outside in the bay in the morning, and sailing out to shoot their nets in the evening. There were a considerable number, about twenty, of similar boats belonging to Scarborough. These had a fore-and-aft rig like the Lowestoft boats, with a foremast which could be lowered on to the deck. But I found that none of them were engaged in drift-net fishing: they were all employed in long lining. I asked a man belonging to one of them, why it was that Scarborough drift-net boats had thus abandoned the work for which they were built, and left the herring fishery in the neighbourhood, which was by no means unimportant, to be carried on entirely by boats from Lowestoft. He said the Scarborough boats could not make the herring fishing pay, and that the Lowestoft men only made a profit out of it because they fished on Sundays.

The real reason is probably that increasing competition has led to more complete specialisation in fishing operations. A few boats which remain at one station and change their mode of fishing according to the season, cannot compete with the large number of Lowestoft and Scotch boats, which are always employed in drift-net fishing, and fleets of which move from one part of the coast to another, making their headquarters wherever herring or mackerel are to be found at the time. The Scarborough boats were forced by circumstances, either to become nomads in the same way, or to find some other profitable employment, and they have found the latter in the long-lining which, in the deeper waters off the north-eastern coast usually affords some return, while off the Norfolk and Suffolk coasts, the conditions favourable to long-lining do not exist.

I was told by a fish buyer that there were only eighteen sailing trawlers and nine or ten steamers belonging to Scarborough, and most of these were landing their fish elsewhere during the herring season. The fish trade at Scarborough Harbour is of no great extent, and when herrings are being landed there is very little market for trawl fish, the salesmen and buyers being unable to spare much attention for them. Many of the steamers are old paddle boats, but there are a few modern screw trawlers.

So far as I could ascertain the question of immature fish does not present itself in an acute form at Scarborough. Inshore trawling has been prohibited by a bye-law of the North-Eastern Committee. When I was there no hand-net shrimping was being carried on, the longshore men being more profitably employed in taking out visitors to sail or to fish in the "cobles" and "mules," as the local shore boats are called. The trawlers fish for the most part in the neighbourhood of the port, on the Scarborough Off Ground, where, the depths being from 30 to 40 fathoms, the fish chiefly taken are large plaice, lemon soles, and haddocks. Plaice, from the German side or Eastern Grounds are not landed at Scarborough. Fishing for soles by hook and line is a remarkable local feature, not to be met with, I believe, anywhere else. I did not gain any personal experience of this mode of fishing, concerning which a good deal of information was indirectly given by Mr. Holt in his account of the Territorial Fishing Grounds of Scarborough in this Journal, Vol. III., p. 176. I ascertained, however, from one of the practitioners, that the instruments used are long lines, furnished with hooks at intervals, and set after sunset in the evening. The lines are of course on a much smaller scale in every way than those used in deep-sea work for larger fish. I examined the hooks, and found them to be 1 in. long and $\frac{3}{8}$ in. from the shank to the barb. The peculiar character of the narrow sandy wykes, supporting a numerous population of annelids, and so attracting numbers of soles in the summer season, is perhaps the reason of the development of line fishing for soles in this locality.

A Fishery Exhibition was held at Scarborough last season, and I had the pleasure of giving a short lecture at it daily for a week. It was organized by Mr. J. W. Woodall, and occupied a wooden building, specially erected for the purpose in that gentleman's grounds on the foreshore. Among the exhibits were a model of Captain Dannevig's Arendal Fish Hatchery, and the collection of various stages of marine food fishes and marine animals, specially mounted for exhibition by our Association.

3. *Hull.*

THE ADOPTION OF THE OTTER TRAWL IN STEAM TRAWLING.

When I was at Scarborough and Hull, last summer, a remarkable revolution was taking place in the steam trawling industry; the old-fashioned beam-trawl, previously in universal use, was being rapidly discarded and replaced by a beamless trawl constructed on the principle of the otter trawl, used formerly only by yachtsmen and amateurs, or for scientific purposes. The innovation was due to the ingenuity and enterprise of Mr. Scott, son of the manager of the General Steam Fishing Company, of Granton, on the Firth of Forth. The modification of the otter trawl, which Mr. Scott invented, will be understood from the following description, and the figures which accompany it, and which are reproduced from those circulated by the inventor's firm. The boards (Figs. 1 and 2) are each 10 feet long by 4½ feet broad, shod with iron, and very thick and heavy. In the centre of the hinder edge of the board is fixed an iron ring, to which the ends of both the head-line and the foot-rope are attached. The head-line is 75 feet long, the ground-rope or foot-rope is 120 feet. The attachment of both head-line and ground-rope to a single ring placed at the end of the axis of the board, is one of the features in which the new gear differs from the ordinary otter trawl, and which are patented. In the ordinary otter-trawl the head-line is attached to the upper corner of the board, the foot-rope to the lower corner, and both are of the same length. Consequently the advantage of the beam-trawl in having the ground-rope, when the trawl is working, some distance behind the head-line, is lost in the ordinary otter-trawl, and a fish disturbed by the ground-rope may swim upwards and rise above the head-line, and so escape the net altogether. In Scott's patent gear this particular advantage in the construction of the beam-trawl is retained, and as shown in Fig. 3, the trawl, when working, has the same shape as the beam-trawl. The net is, therefore, constructed with a square piece of netting in the front part of the upper side or back, a piece technically known as the "square," and 58 feet in length. (Fig. 1.) The only other peculiarity on which the patent depends is the arrangement of the two triangles of iron on each board, to which the towing ropes are attached. The advantage claimed for these is, that being rigid, they ensure that the strain on the board shall always be in the right direction, and if the strain should be temporarily interrupted so that the boards fall on the ground, nothing can easily get foul.

The trawl is towed, not by means of two bridles and a single towing rope, but by two separate ropes, one from each board, one of which is

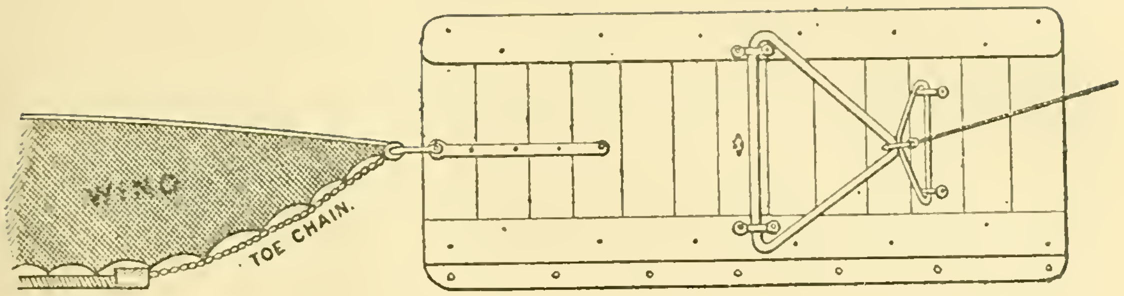

WING
TOE CHAIN.

FIG. 1. Side view of Board.

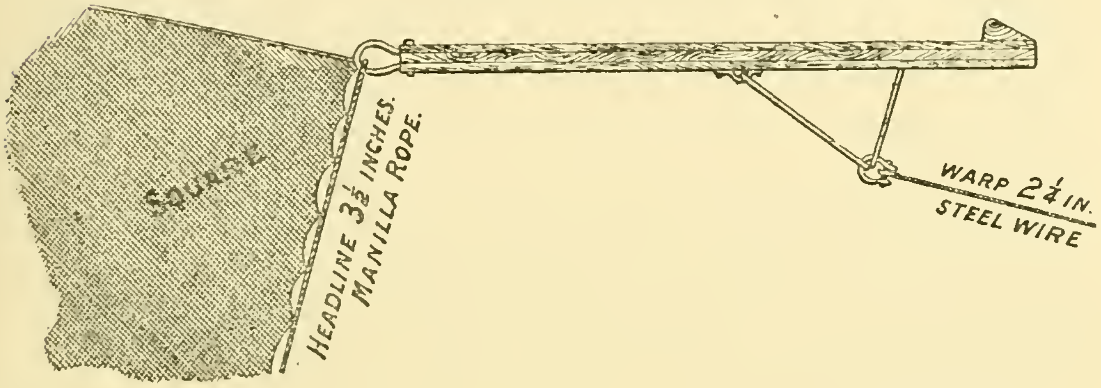

SQUARE
HEADLINE $3\frac{1}{2}$ INCHES. MANILLA ROPE.
WARP $2\frac{1}{4}$ IN. STEEL WIRE

FIG. 2. Board seen from above.

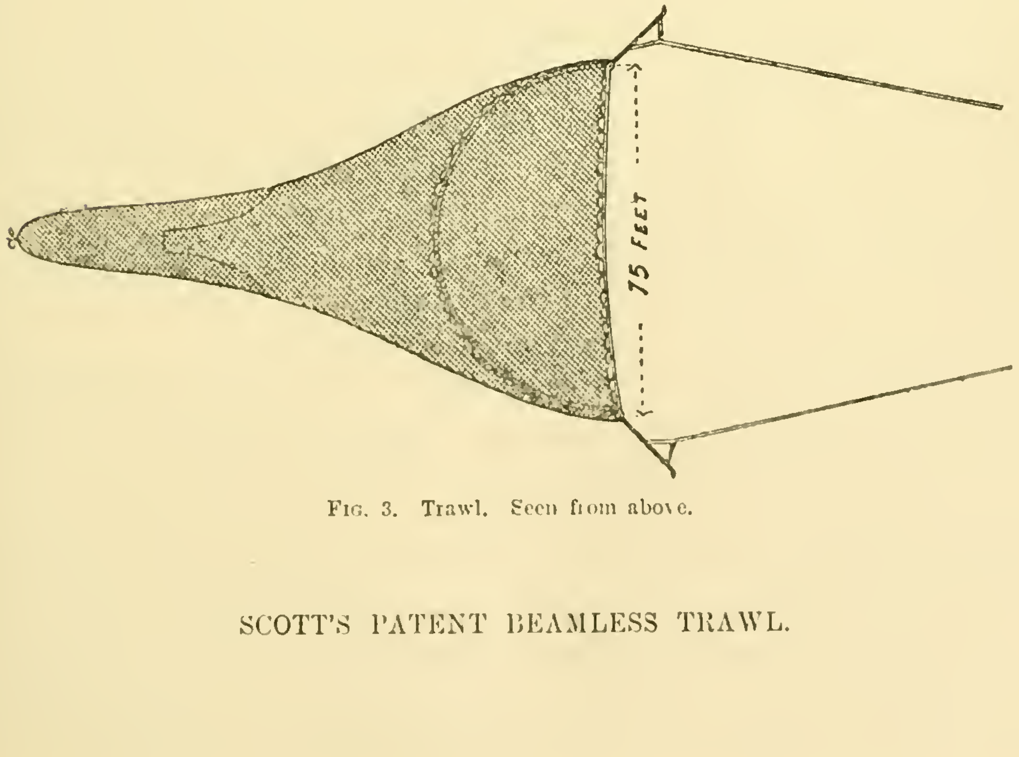


FIG. 3. Trawl. Seen from above.

SCOTT'S PATENT BEAMLESS TRAWL.

brought up over each quarter of the vessel to the steam winch. For hoisting in the gear, two oblong wooden frames are used, each resembling a gallows, with an upright on each side, and at once named gallows in the figurative language of the fishermen. These were at first fixed on the rail of the vessel, one near the bows, one on the quarter, and, when the gear was up, the boards were secured to these frames, so that they were out of the way and incapable of doing harm through being dashed about by the waves or the motion of the ship. The frames were afterwards fixed on the deck inside the bulwarks, the boards being allowed to drop between them and the latter when not in use, an arrangement which was thought to be still more convenient.

The advantages claimed for this gear are (1) That it catches more fish per haul on account of its much greater breadth; (2) That it catches round fish, such as haddock and cod, in the daylight as well as at night, whereas the beam-trawl catches much fewer in daylight; (3) That there are no beams to break, and no new drawbacks to neutralise this advantage.

Concerning the greater efficiency of the patent trawl, which is stated to be as much as 50 per cent. more than that of the beam-trawl, there seems to be no possibility of doubt. It has been proved by experience, and by the rapidity with which the new gear has been adopted.

At Hull the steamers first fitted with the patent gear frequently caught twice as much fish, and made twice as much money, as those still using the beam-trawl. One steamer, after a voyage of seven days, fishing on the Holman Ground, *i.e.*, off Hantsholm, in the North of Denmark, landed 400 kits of fish, of which 80 kits were plaice. The kit contains 10 stone, the box used at Grimsby containing about 9. On this voyage the skipper said *he threw all his haddock, both small and large, overboard during the first three days*, because they would fetch less money than the plaice and cod. The value of this "voyage" of fish was £196. The causes of this greater efficiency are two; firstly, the greater extent of ground covered by the new trawl; secondly, the fact that it catches round fish in the daytime. It is obvious that, other things being equal, the new trawl must catch more fish in consequence of its greater extent. A trawl beam does not exceed 45 to 50 feet long, and could not be increased without a considerable increase in the size of the ships and their machinery, while the head-line of the beamless trawl is 75 feet long, and may be more. I have not heard that the beamless trawl catches as many soles in the daytime as at night, the reason for the fact that these are caught more at night being their nocturnal habits; in the day they remain buried in the sand. But with the beam-trawl it was nearly always found that more cod and haddock were caught at night, and some fishermen believed that this was because they swam some distance above the bottom during the day. The fact appears to be that the movement of the beam through the water, and its size, alarms the fish in daylight, and that they see it while they have time to avoid it. With the beamless trawl, on the other hand, there is scarcely anything to be seen or to create alarm. It is probable, too, that the head-line of the beamless trawl is not stretched quite straight in the water by the boards, but rises upwards towards the centre, and for this reason a fish would have more difficulty in avoiding the mouth of the net.

Mr. Scott was led to turn his attention to the improvement of the trawl, in consequence of the gradual diminution in the earnings of the Granton Steam Fishing Company. After various experiments he elaborated and patented the mode of construction above described, and the new apparatus was fitted to some of the Granton Company's vessels in June, 1894. He then chartered three steamers on his own account, had them fitted with his patent gear, and caused them to fish for a time out of different ports in succession, finally taking them to Hull, where he was established at the time of my visit. The new gear was first adopted in Hull by the Anglo-Norwegian Steam Fishing Company, and afterwards by other firms. Mr. Scott informed me that, at the time I was in Hull, it was in use on sixteen or seventeen steamers in that port, on eight at Granton, on one at Boston, two at Grimsby, and two at Milford Haven, and I also saw it on one at Scarborough.

The patentee, however, charged a considerable sum for the right of using his patents. I heard that the charge was £100 a year, but it will be understood that I was not anxious to obtain, or to publish, information which business men might consider to be in some degree of a private nature, and am only concerned with these matters as far as they are of public interest. Whatever the amount of the charge, it is a fact that many owners of steam trawlers in Hull thought they might obtain the advantages of the beamless trawl without rendering themselves liable for the charges of the patentee, or infringing the patent rights. Their view was that the principle of the otter-trawl was free to everyone, and that the patented special features were not essential. Accordingly, a large number of steamers were fitted with beamless or otter-trawls of a somewhat different construction. The boards of these were smaller and lighter than those of the patent gear, being each about six to eight feet long, and four feet broad. The hinder edge of the board was provided with holes along its whole length at equal distances, and the ends of the head-line and ground rope were shackled into these holes separately. Thus the attachments of the two ropes could be made near together or far apart at pleasure. The head-line was made 74 to 94 feet long, and the ground rope longer, and the net was made with a "square" in the back as in the patent trawl. The attachment of the towing rope to the board was made by means of four short iron chains fixed to the board at four separate points.

These unpatented beamless trawls were working with apparently satisfactory success at the time of my visit, which lasted from August 27th to September 5th. In working them no frames were used for hoisting, but the towing ropes were brought in over the pulleys fitted in the bulwarks forward and on the quarter rail for hoisting the beam trawl. The boards were simply hoisted over the rail, and stowed on deck when the trawl was hauled. Other contrivances were being tried for greater convenience in handling the gear. On one vessel I saw an aperture being made and fitted with rollers in the bulwarks of the quarter, similar to that which was used in the fore part of the ship in hoisting the beam trawl. In fact, at the time I was in Hull, it was very remarkable to see the amount of work going on all about the fish dock, in connection with the construction of new trawls and the fitting of new contrivances on the vessels for their more convenient operation, while collections of discarded beams and iron trawl-heads were lying neglected in various places.

From the circumstances of the case, and from a few trials that had been made, it did not appear possible to use the beamless trawl with advantage on sailing vessels. Its use apparently requires a strain that shall be constant and not below a certain degree of strength, so that a sailing smack could only use it when the wind was steady, and fairly strong, and, under ordinary conditions, would be better off with the beam trawl. It is evident, therefore, that the greater efficiency of the new gear on steam trawlers makes the inferiority of the smacks greater than it was before—and even before they had considerable difficulty in earning enough for their maintenance.

Another question which arises from a consideration of the greater efficiency of the beamless trawl, is its probable effect on the available fish supply. It is true that its chief advantage lies in the greater number of haddocks and cod it captures to supply a demand which is usually all but insatiable, and a failure in the supply of haddock has not yet made itself very evident. I have not at present any evidence of importance of the use of the new gear on grounds which produce soles, but it certainly brings in an increased number of plaice, *e.g.* from the Holman Ground. Probably, therefore, as the supply of plaice has already diminished, the advantage of the new gear with respect to this fish can be only temporary, and we may expect that, in a few years, a trawl spreading 75 ft. will not be able to capture more plaice than the beam-trawl of 50 ft. could in the year 1895.

Although compelled to adopt it by the necessity of self-preservation, many of those who depend on the fishing industry at Hull have not rejoiced at the introduction of the new gear. When I was at Scarborough I attended, by Mr. Woodall's invitation, a small conference, held at the Exhibition, to discuss the artificial propagation of marine fishes. One of the gentlemen present, who belonged to Hull, argued that it was absurd to consider the proposal to hatch fish-eggs, when the new beamless trawl was bringing in such numbers of small haddock that the market was glutted with them. Another gentleman replied to this that, in the warm weather of the middle of summer, gluts of haddock had occurred in previous years, though always of very temporary duration, and that there was never any glut of plaice, soles, or turbot, which were the fish it was proposed to propagate.

The following week I was at Hull, and enquired, as far as I could, into the circumstances of the glut. I found there had been no excess in the supply of any other fish but the small haddock, and satisfied myself that the use of the new trawl did not involve the capture of any more small fish of any kind in proportion to the total catch, than the beam-trawl. It was the fact that the supply of small haddocks in the previous week had exceeded the demand. But these were haddocks of a size which are always brought to market, namely, from 9 in. to 12 in. in length, and they are chiefly bought for the fried fish shops, whose custom falls off in summer time. One vessel landed 500 kits of these, and only 200 kits were sold. The manure works took a good many, but they were also glutted. During the week that I was in Hull, many of the vessels threw overboard their small haddock, to avoid the same disappointment again, and it happened that prices were so good that they had reason to regret doing so. On September 2nd the price was 8s. to 10s. a kit, while on the next day it fell from 6s. to 2s. in the course of sale.

The headquarters of the fishing industry at Hull are at the St. Andrew's Dock, the most western of all the docks of the port. A new and larger dock for fishing vessels is in course of construction, on adjoining ground on the west side of the existing dock, which does not now contain sufficient accommodation for the increased business. No other fishing is now carried on from this port except deep-sea trawling, and long lining, and the latter branch of the industry is only pursued by about a dozen steamers. A large number of sailing smacks, 250 according to the annual reports of the Inspectors, are still owned and managed at the port. All of these are worked on the fleeting system. The principal fleets are the Red Cross and the Great Northern, and the fish from these is conveyed to London by steam carriers. At present a considerable number of steamers are regularly employed in fishing with the fleets, and the statement in the *Eastern Morning News* of September 1st, that, on the previous day, the "cutter," or carrier, from the Red Cross Fleet was in London with fish from 19 steam trawlers and 64 smacks, and the Great Northern cutter with fish from 10 steamers and 70 smacks, illustrates the extent to which this practice has been carried.

The local market at the St. Andrew's Dock is supplied almost entirely by steam trawlers. A great deal of the variety in the modes of fishing and in the kinds of fish brought to market at Grimsby, is missed by the visitor to Hull. The Hull market has not such extensive relations as that at Grimsby, and does not offer the same demand or price for prime fish. The Hull trawlers, therefore, attach more importance to quantity than quality, and one does not find either smacks or steamers there, as at Grimsby, which make a special point of fishing for soles, turbot, and brill. There are no welled cod-smacks, or cod-chests, in the dock, and the line fishing for halibut, tusk, cod, ling, skate, etc., on the distant grounds of Faröe and Iceland, is not pursued to the same extent as at Grimsby. During my visit a number of the steamers landing their fish at Hull were fishing on the Holman Ground, and in the Skager Rack, or Sleeve, as the fishermen call it. One steamer, using the otter-trawl without the patented arrangements, landed 82 kits of plaice, 45 kits of large haddock, 58 kits of medium haddock, 24 kits of cod, 5 kits of codling, 2 kits of hake, 6 kits grey gurnard, 8 stone turbot, 13 stone halibut, 3 score cat-fishes, 5 score ling, 5 score skate, 4 score rays.

The Hull market does not offer such good facilities for observation as that at Grimsby. The fish, as it is landed in baskets on the quay, is nearly all weighed, and then thrown into the kits, which are somewhat narrow deep open casks, and when these are moved away for sale, the various parts of a single vessel's catch are not kept together. To ascertain the nature and amount of a vessel's catch, it is necessary, therefore, to watch the whole process of landing, whereas at Grimsby the wide shallow boxes, and the fact that the whole of a vessel's catch is placed together in one spot on the pontoon, enable one to see at a glance what a vessel has landed.

The Hull steamers, and the fleets too, fish a good deal in spring on the Eastern or small plaice grounds, but while I was in Hull the quantity of fish on these grounds was too small to remunerate them. I ascertained in the case of three steamers that they had visited these grounds and fished there for a part of their voyage, but none of them landed the smallest plaice which are usually there. None of the plaice landed in these cases were less than 9 in. long, and the largest quantity landed from one vessel was 30 kits, the largest fish not exceeding 16 in.

It is important, however, to note that the beamless trawl, with its enormous spread, has been already used on these grounds, and it may be expected that next spring it will sweep up the small plaice in more wholesale fashion than the beam trawl has done in previous years.

The other vessels concerning which I made enquiries, had been fishing in the neighbourhood of the Dogger, from which one vessel, after a voyage of eight days, landed 31 kits of rather small plaice, 12 kits of large plaice, and 180 kits of haddock.

I did not see at Hull any small vessels employed in fishing in the Humber, or in territorial English waters.

4. *Lowestoft.*

I arrived in Lowestoft on September 5th, and the next day saw a heap of small soles in a fishmonger's shop. I bought a sample of these and found it consisted of 4 immature females 7¼ in. to 8¾ in., and 3 immature males 7 in. to 8¼ in. No less than 4 of these 7 soles were under 8 in. in length, and I found afterwards that soles similar to this sample were frequently on sale at the same shop. It naturally occurred to me that this observed fact was strikingly inconsistent with the statement made to the Parliamentary Committee of 1893, that soles under 8 in. in length were never brought into the Lowestoft market in sufficient quantities to make a sale of them. On referring to the Report of the evidence taken by that Committee, however, it appeared that the statement in question was made in reference to the trawl market, and was intended to refer to the trawlers. I found that the soles which I examined were caught in the inshore waters by the shrimpers, two of whom gave evidence before the Parliamentary Committee. One of them stated that they threw the undersized soles overboard alive, the smallest kept being between 7 and 8 in. My own observation shows that the limit is as low as 7 in.

On September 17th, I had a conversation with the master of one of the shrimping boats in Lowestoft Harbour. He had just come in from his morning's work. The boat was open, and rigged with two masts, carrying two lug sails. There was only one trawl on board, an ordinary beam-trawl of 15 feet beam, the net of shrimp-mesh at the cod end. The man informed me that there were about forty such boats at Lowestoft, and they were to be seen moored in the outer harbour, though I could not count them. They were not all at work at this season, many of the men being employed in the herring and mackerel boats. The principal shrimping season is from May to August.

The shrimps brought in by this boat had been sent away for sale; but there were some fish on board—plaice, soles, and whiting—evidently of no great value, as the man allowed me to take what I pleased from them for a shilling. Those that particularly interested me were 3 small soles, true *Solea vulgaris.* They were 2¼ in. to 2⅝ in. long, and could be confidently considered to be of the year's brood, hatched in May and June, and therefore three or four months old. I have shown that in the Plymouth Aquarium a sole ⅝ in. long in April grew to 3¾ in. on the following September 2nd. These small soles were not brought in intentionally, but had simply been overlooked when the rest of the valueless part of the catch was thrown overboard. The other fish in the boat were brought in for sale. I took all the soles; their sizes were—3 at 6¾ in. length, 2 males, 1 female; 1 at 7¼ in. length, female; 1 at 7⅞ in. length, female; 1 at 8¼ in. length, female; 1 at 8½ in. length, female; 1 at 9⅛ in. length, male.

All these were immature. If we apply here the method of the Danish biologist, Petersen, and notice the sizes at which the greater number of specimens group themselves, although the number of specimens is small, it is clear that we have at least two groups, those of the first year and those of the second, the former being 2 to 3 in. long, the others mostly about 7 in.

The plaice from this boat were few in number. Their sizes were—1 at 7⅞ in., female; 2 at 8 in., female; 1 at 9½ in., female; 1 at 9¼ in., male; 1 at 11 in., female.

In order to examine the ground where the small boats worked, and their methods of operation, I accompanied the master of this boat on one of his trips. We went out at 6.30 a.m., on September 18th. The trawling took place on the Newcome Sand, which stretches parallel to the shore from Lowestoft southwards. It is separated from the beach by a channel 4 to 5 fms. deep at low water, the depth on the sand itself being only 1½ to 2 fms. The flood was going up, *i.e.* south, and we towed with the tide, with the wind on the starboard side, off the land.

When the net was hauled the first time, there were a large number of the small soles of the year's brood, about 2½ in. long. I counted 42.

Plaice of corresponding size were extremely scarce; there was only 1 2¼ in. long, and 1 dab 1¼ in. 7 soles were kept for market, 6 to 9 in. long; there were 2 marketable dabs, and 4 marketable plaice, 7 to 10 in. long; also 1 large plaice, 22¾ in. long. There were 9 marketable whiting.

Second haul, same direction. Of the smallest soles, 22 were thrown overboard, besides some which I kept.

After this, having passed the Barnard Buoy, which is near the end of the Newcome, we shot off Kissingland Lifeboat House, and steered north again nearer the shore.

Third haul, a short one, the trawl having caught fast. There were 17 soles 2 to 2½ in. long, 6 soles about 6 in. long.

Fourth haul, same direction. There were caught 23 small soles about 2¼ in. long, a number of whiting, some of the previous year's and some of the same year's broods. Many of the latter were thrown overboard; the size of these is stated below.

Fifth haul, a long haul northwards towards Lowestoft Harbour on the ebb tide. I counted 38 of the small soles when the cod end was first emptied out, besides a large number picked out in the process of sorting afterwards. There were also some whiting and small plaice, mostly kept for market.

The mode of working was as follows:—When the trawl was hauled, the cod end was emptied out into a wooden box in the boat. There were always a number of the little soles in the meshes of the net, alive and apparently, in most cases, uninjured. Except those which I kept, they were all thrown overboard alive. There was always a large quantity of Hydroids, chiefly *Hydrallmania* and *Sertularians*, with pieces of red seaweed occasionally. A considerable number of fish of unsaleable kinds were also taken, namely, *Agonus cataphractus*, *Trachinus vipera* (the lesser weever), *Gobius minutus* (the sand goby), one or two small *Syngnathus* (pipe-fish), a small *Acanthias vulgaris* (spiny dog-fish), and a small *Galeus vulgaris* (locally called "Sweet William"). The invertebrates were some *Portunus*, or swimming crabs, *Carcinus*, the shore crab, one *Cancer* (edible crab), a number of Isopods and Amphipods, including *Idotea* and others. We also took several living specimens of the bivalve *Mactra stultorum*, var. *cinerea*, Gwyn Jeffreys. These things were all thrown overboard. The marketable fish were placed in a separate box, and then the shrimps were riddled over the side and the sorting completed, after which they were placed in a basket to be taken ashore. The shrimps were thus not as in the Thames shrimping boats, which are much larger, boiled on board. There were no *Pandalus*, or pink shrimps, only the brown *Crangon vulgaris*, and the catch of the whole trip amounted to about two pecks. The man told me that there had been little "call" for shrimps that season, and his earnings had not averaged more than £1 a week. The only assistance he had in the work was that of his son, a lad of seventeen. The boat was the property of a widow, whom he paid for the use of it.

I brought ashore a large number of the whiting caught, and measured them to see if I could distinguish the broods of different years by Petersen's method. The lengths in inches were as follows:

Length.	Number of Whiting.
3 in.	9
4 in.	12 } maximum.
5 in.	12
6 in.	2
7 in.	4
8 in.	7 maximum.
9 in.	4
10 in.	2
11 in.	2
12 in.	1

It will be seen that the number of fish was at a maximum at two sizes, namely 4 to 5 in., and 8 in. The former length is, therefore, that of the majority of the whiting of the year, hatched in the previous spring, and the latter that of those in their second year.

The results of examination of the contents of the stomachs in the small soles are of interest. It is known that the larger soles feed almost entirely on worms, but in these young specimens I found only small Crustacea, with a certain quantity of sand. In one was a Copepod, in three were specimens of Cumacea, minute Crustacea which live on sandy ground. The smallest sole was only 1½ in. long. Plaice and dabs of the year's brood were remarkably scarce; there were 3 dabs 1½ to 1¾ in., 1 plaice 1⅞ in., and 4 plaice 3¾ to 4½ in.

Of larger soles which I brought ashore there were 8 of 5 in., 2 of 6 in., 1 of 9¼ in. The food in all these was the tail end of the lug-worm, Arenicola.

The chief interest of this ground is, of course, the very considerable number of soles of the year's brood, as well as of those of a larger size, 6 to 8 in., and a year old, which occur upon it in September. It is by no means certain that any great injury is done to the little soles which are trawled and thrown overboard again, though probably a certain percentage of them are thereby killed. But it is clear, I think, that a limit of 10 in. for the landing and sale of soles would be a distinct and very beneficial protection to this species on this ground, and could do no great injury to the men who get their living from the inshore trawling.

The next branch of the industry at Lowestoft to be considered, and one which is vastly more important than the inshore trawling, is the deep-sea trawling. This is carried on exclusively by sailing smacks. The absence of steamers at Lowestoft is largely due probably to its greater distance from the coal and iron centres as compared with Hull and Grimsby, and the more northern ports generally. It is true that the steamers could be built elsewhere, and the coal and other requisites could be conveyed to Lowestoft. But the grounds in the immediate vicinity are not extensive enough, nor productive enough, to enable a steamer to pay a profit on her working, and if she is to work the grounds more to the northward, she finds a more convenient port for landing and working from, in Hull, or Grimsby, or Boston. In fact, the scarcity of haddock and cod in the shallower waters of the narrow southern part of the North Sea is alone enough to account for the absence of steam trawlers, and their failure, when they have been tried, at the East Anglian ports.*

The number of trawling smacks at Lowestoft is stated, in the Inspector's Report for 1894, to be 320. They are all ketch-rigged and provided with steam capstans. In size they are smaller than the majority of the Hull and Grimsby smacks, the largest being not more than 60 tons. The crew of each consists of four men and a boy, the latter acting as cook. It is a remarkable fact that all these vessels land their fish at Lowestoft, each one landing its own. The boats do not practise the fleeting system, and none of the fish is sent to London direct from the smacks by sea. At Yarmouth it is just the opposite, the trawlers there all fish in fleets, and their fish is conveyed to London by steam carriers. Some few years ago there were few fish buyers at Lowestoft; the usual custom of smack owners was to send the fish to London by railway, and there it was sold on commission by the salesman at Billingsgate or other market. But now the fish is sold by auction when landed, as at Grimsby or Hull, and the smack owners and fishermen have no further interest in it. The same man is sometimes both buyer and smack owner, or has interests in both branches of the business, but, nevertheless, the two branches are perfectly distinct. I was assured, and the prosperity of the industry at Lowestoft is good evidence of the fact, that prices have been better, and the profits of fishermen and smack owners greater, under the present system. This is certainly one case in favour of the much-accused middleman. It is not difficult to understand that under the circumstances of the fish trade the "buyer" performs a very useful function. It is his special business to know where to place his fish according to the demand, and thus the Lowestoft smacks have the whole country opened to them, instead of being restricted to London, or any other single market. Moreover, a man who has paid for the goods he has to sell, and deals with them at his own risk, is naturally more interested in finding a market for them than the man who sells on commission, the chief risk being borne by the consigner.

---

* In the Inspector's Report for 1894 it is stated that 10 steamers were working from Yarmouth. Probably several of these act as carriers for the fleets.

The harbour at Lowestoft is divided by wooden piers into several compartments, and one of these is allotted to the use of the trawlers, the market for trawled fish extending along the side of it. During my stay I was allowed to use one of the small offices in this market for my work, and I received a great deal of assistance and courtesy from members of all classes of men engaged in the fish business, from fishermen, smack owners, and dealers, for which both personally, and on behalf of the Association, I am glad to express my thanks. I was especially indebted to Mr. Sladden for permission to make a voyage in one of his boats, and to Mr. Alfred Turner for information and guidance in the market.

I have mentioned in the first section of this paper that the Lowestoft smacks were during my visit trawling partly in the neighbourhood of the Brown Ridges, partly around the banks and shoals off the English coast to the northward, from the Smith's Knoll and Winterton Ridge to the Outer Dowsing. The smacks usually remain out for seven or eight days and more of them land fish on Sunday than on Saturday, for the reason that buyers prefer to send fish for Monday's market on the former day than on the latter. On September 9th a smack, which had fished 55 miles E.S.E. of Lowestoft, at depths of 11 to 23 fathoms, landed 18 boxes of rather small plaice; 4 boxes of dabs; 1 box (level) of soles; ½ box of turbot; 2 or 3 rays. A box of these plaice contained 109 males, 117 females, and the size was 9¼ in. to 15 in. The price was 8s.

A catch on the same date from the Swarte Bank, which is on the English side, a long way to the N.W. of the Brown Ridges, consisted of 8½ boxes plaice; 1 box dabs; 1 box (level) of soles; 1 box turbot and lemon soles; 1 box dabs; 1 box rays; 1 box haddock. The largest plaice was 21½ in., the smallest 9½ in.

There were frequently seen in the market large heaps of mixed fish of little value. They consisted of a few small plaice, dabs, and chiefly of gurnards and large weevers (*Trachinus draco*). I afterwards found that these fish came from the neighbourhood of the Brown Ridges. The gurnards in these heaps were the grey gurnard (*Trigla gurnardus*) by far the most numerous, the red gurnard (*T. cuculus*) and the tub or the latchet (*T. hirundo*). Catches from the eastern side also often included a box or half a box of large latchets. The number of boxes of plaice varied from 15 to 25. Haddocks and lemon soles were conspicuous by their absence. On September 20th, at 10.30 a.m., I counted all the small plaice in the market, and found there were 440 boxes; but this does not include all landed in the day—some had already been removed, and others were landed later. The fishermen, in packing their plaice, reserve all the largest for putting at the tops of the boxes, and for this reason the appearance of the small plaice from the eastern side is quite different from that of the plaice from the banks off the Norfolk coast, the largest visible fish in the former case seldom exceeding 16 in., in the other reaching 22 in. or more.

In the catches landed from the Norfolk coast, latchets and weevers are not seen, while some haddocks and lemon soles are usually present; but the number of both these kinds is very small, one box of haddocks and half a box of lemon soles being the usual limit. Plaice from these grounds are less plentiful than from the eastern. A voyage from Smith's Knoll and Leman Shoal comprised 3 boxes plaice; 2 boxes lemon soles; 1 box soles; 1 box turbot and brill; 1 box dabs; 3 boxes whiting.

Another voyage from the Leman Shoal was 12½ boxes plaice; 3 boxes dabs; 1 box soles; 2½ boxes lemon soles; 1 box turbot and brill; 1½ boxes codling; 1½ boxes of haddock; ½ box whiting; 3 boxes rays or roker.

A voyage, stated to be caught off the Winterton Shoal, landed on October 9th, contained 8 boxes rather large plaice; 1 box roker and whiting; 1 box dabs; 1 box soles; ½ box turbot and brill; 1 box cod, and haddock; 3 boxes whiting. The Winterton Shoal is about 15 miles from the coast to the north of Yarmouth, the depth where these fish were caught 16 to 19 fathoms.

A voyage from the "deep water," 20 miles off Lowestoft, consisted of 10 boxes small plaice; 1½ boxes soles; ½ box lemon soles; 4 boxes cod, 2 boxes whiting; 4 conger.

On Wednesday, October 9th, I saw a boat landing a catch with scarcely any plaice, only a dozen small specimens altogether. The skipper said he went out on the previous Saturday, and had been fishing in the "deep water." He had 1½ boxes of soles, ¼ box of slips or small soles, 1½ boxes of rays, ½ box of lemon soles, a few soles, a few brill, 1 box of whiting, and 1 box of whiting and codling. The number of small soles was remarkable, many were under 10 in., and some no more than 7 in. in length. The box of soles was sold for £9 15s., the slips for 25s.

It is well known that level ground, less than 20 fathoms deep, stretches in a W.N.W. direction from the Dutch coast to the Swarte Bank. I cannot say how far the *smaller race* of plaice, which I have shown to exist at the Brown Ridges, extends, but a voyage landed on October 8th, caught 25 miles east of the Swarte Bank, was apparently similar to one from the Brown Ridges. It included 40 boxes of small plaice, 1 box of latchets, ½ box of soles, 1 box of turbot and brill, 1 box of cod, 3 boxes of dabs. There were no haddock or lemon soles.

These indications are useful in giving a correct picture of the character of the trawling at Lowestoft, but the products of the grounds can be more completely examined on board a vessel during her fishing. I made one voyage on a smack from Lowestoft, and was able to ascertain very thoroughly the character of the ground called the Brown Ridges.

We sailed out of the harbour on Monday, Sept. 23rd, and steered to the east in fine weather, with a light breeze. The skipper informed me that £20 was a large sum for the catch of one of these vessels, that they did well if they got £800 in a year as total gross receipts.

At noon on Tuesday our skipper took an observation of the sun, and made our latitude to be 52° 41′. We shot the trawl at 2.30 p.m. Our distance from the English coast I do not know exactly, as we could not log it as the steamers do, but it was between 50 and 60 miles, and about 40 or 50 miles from the Dutch coast. At first we towed towards the south, and at 5 p.m. we tacked round, and towed northwards. At 6 p.m., the depth was between 19 and 20 fathoms.

The trawl was hauled at 11.30 p.m., having been down nine hours. There was a fair quantity of fish in the net, consisting of rather small plaice, whiting, weevers, latchets, and gurnards. There were a large number of small whiting, dabs, and grey gurnards. The smallest plaice was 9¾ in. long, the largest 17¾ in., and none were thrown overboard. The fish kept for market were: 3½ baskets of plaice, 9¾ in. to 17¾ in.; ½ basket of dabs; ½ basket of latchets, largest 20 in. long; 1 brill; 1 turbot; 9 pair of soles. The larger dabs were saved, and all the smaller thrown overboard; the smallest was 4½ in. long. All the whiting, weevers, and gurnards—about a trunk full altogether—were thrown overboard, but not the latchets (*Trigla hirundo*), which, though a species of gurnard, are of larger size. These fish—weevers, small dabs, whiting, and gurnards—are saved from the last hauls, but do not pay for icing if kept from the first day or two of the voyage. The weevers were of two kinds, the small (*Trachinus vipera*) and the larger (*Trachinus draco*). There was one scaldback (*Arnoglossus laterna*), a female mature, and two dragonets (*Callionymus lyra*). Of invertebrates there were 1 squid, starfishes, a few hermit crabs, and whelks.

The trawl was shot again at once, and the second haul was made at 10 a.m. on Wednesday, trawl having been down about 10 hours. At 9 a.m. we sounded 13 fathoms, being then on one of the ridges. The marketable fish from this haul were: 2 trunks of plaice; ½ basket of dabs; ½ basket of gurnards, whiting, and weevers; 10 latchets; 5 pair of soles.

The largest plaice was 16¼ in., evidently ripening for next season, the smallest was 9¼ in., a female immature. The smallest sole was 10 in. long.

About a trunk of small whiting, dabs, gurnards, and weevers were thrown overboard. The largest weever (*T. draco*) was 13¼ in. long, the smallest (*T. vipera*) 2¾ in. There was one solenette (*Solea lutea*).

Of invertebrates there was 1 edible crab, 1 *Astropecten*, 1 *Spatangus purpureus*, and a great number of large hermit crabs (*Eupagurus bernhardus*) in whelk shells.

We did not shoot again at once, but sailed to the southward and eastward, the wind having taken us too far to the north, or "down," as the fishermen term it.

At noon our latitude was 52° 44′. At 3 p.m. I took the surface temperature of the sea, and found it was 62°.0 F. The density was 1027, as well as I could read it in a bucket on deck.

At 5.45 p.m. the trawl was shot again, the ship's head being N.E., and the wind from the east. We hauled at 6.30 a.m. the next day. There had been a calm all night, and in the net were only 1 pair of soles, about 12 plaice, and a few small gurnards, dabs, and weevers. The net was much torn.

We could not shoot all day for lack of wind, but put the trawl over at 6.30 p.m., again towing to the north with the wind from the eastward. We hauled at 7.45 a.m., and again had scarcely any fish, the wind having been very light. There was 1 turbot 18½ in. long, a male, mature. There was about ¼ of a trunk of plaice, 8 soles, 10¾ in. to 16½ in. long, and, as usual, some small whiting, gurnard, weevers. The plaice were 11 in. to 16¾ in. long. There were 1 *Astropecten*, 1 sandstar (*Ophioglyphya lacertosa*), and several *Echinus miliaris*, and common starfishes.

The trawl was shot again at once, and hauled at 7 p.m. The latitude at noon was 52° 36′. Still the wind was deficient. The novel occurrence this haul was a piece of black friable substance, which the men called "moor-log," apparently a submarine soil or peat.

There were 1 turbot 17¼ in., and 1 brill 16¼ in., the latter a mature male, half a box of plaice and dabs, and 1 pair of soles. There were 5 dragonets (*Callionymus lyra*) and the usual invertebrates.

The trawl was shot again immediately, and hauled at 8 a.m. the next day, after about 12 hours. This time a fair quantity of fish was brought up. The marketable portion was, 5 trunks of plaice, largest 16½ in.; 3 trunks of whiting and dabs, smallest dab 7 in., largest 13 in.; ½ trunk of soles, 40 pairs and 2 or 3 slips; 3 latchets, 3 rays, 12 in. across pectorals.

The largest whiting was only 12½ in. long, the smallest 8 in. There were two scaldbacks, one 3¾ in., and one 5 in., neither having the fin-rays elongated. The smallest sole was 8¼ in. long, the largest 18 in. About a trunk of small gurnards, small dabs, small whiting, and a few weevers were thrown overboard.

In one of the plaice which I opened, the food was chiefly *Pectinaria,* a worm which builds a pretty, smooth, conical tube out of grains of sand. The invertebrates, as usual, included starfishes and hermit crabs, but there were also numerous lumps of *Alcyonium,* or dead man's fingers, and one piece of *Antennularia.* Hydroids were absent from all the other hauls.

The trawl was not shot again until 12.30 p.m., the interval having been spent in sailing to windward, *i.e.* to eastward. It was hauled at 10.15 p.m. There was a great mass of "moor-log" in the net, measuring 2 ft. by 18 in. by 8 in. It contained a number of specimens of a boring mollusc, probably *Pholas.* The marketable fish were:—2 trunks of plaice; ¾ trunks of dabs; 10 soles, 9¾ to 14¼ in.; 3 latchets, largest 17½ in.; ¾ trunk grey gurnards, 7 to 12 in. long; weevers many, largest 13 in. long. The smallest plaice was 9¼ in. long. The gurnards and weevers were saved for market, as in consequence of the lack of wind and scarcity of fish, they were expected to make 1s. a box. Among the worthless fish were some solenettes, one scaldback *(Arnoglossus laterna),* one tope *(Galeus vulgaris),* and a few dragonets. In the stomach of one large weever which I opened were two sand-eels. The invertebrates were large numbers of common starfishes and *Astropecten,* and some anemones *(Actinoloba dianthus).*

The trawl was shot again immediately, and was hauled again for the last time at 10.30 a.m. on Sunday, September 29th. On the net were a piece of *Halidrys siliquosa,* two pieces of *Tubularia larynx,* and swarms of small Amphipods; also some pieces of a branching Polyzoan.

The marketable fish were:—2 trunks plaice: 1 trunk dabs; 2 trunks gurnards, mostly rather small; 8 pair soles; 2 turbots; 1 brill. One of the turbots was 19½ in., male mature; one 18¼ in., female, apparently mature. The brill was 17¼ in., female mature. There was one lemon sole. The smallest plaice was 9¼ in. long. There were no whiting, some larger weevers, but few of the smaller species. Of invertebrates there was one living *Natica,* and there were several shells of this form containing hermit crabs.

After this we made sail for Lowestoft; our latitude, at noon, after a short run, was 52° 19′.

A comparison between the above observations and those made on the ground off the German coast, north of Heligoland, at the beginning of June, and recorded in the previous number of the Journal, shows completely the differences and resemblances between the two districts. The difference in latitude is about 2°, the central part of one district being 52° 30′; of the other 54° 30′. The distance from the Dutch coast of the southern ground is mostly between 30 and 50 miles, of the northern from the German islands, between 10 and 25 miles. The depth on the southern ground was 13 to 20 fathoms, on the northern 7½ to 14 fathoms. It is plain, therefore, that the ground of the Brown Ridges is considerably deeper and farther seaward than that which I studied in June, in the s.s. *John Bull*, from Grimsby.

The comparison of the fish on the two grounds is as follows:—

The *plaice* on the northern ground did not exceed 17 in.; the largest was 16¾ in. long. On the southern ground very few plaice exceeded this limit, but I measured one which was 17½ in. long. On the northern ground the minimum length of plaice was only 5 in., while in the southern none were taken which were under 9 in. On the northern ground two or three basketfuls, or even more sometimes, of small plaice under 10 in. were thrown over at each haul; on the southern ground there were no such fish to throw away. The difference in the maturity of the plaice has been fully stated in a previous part of this paper. The relative abundance of the plaice it is not possible to estimate, as the fishing in one case was by a steamer, in the other by a sailing smack.

Turbot and brill. The smallest turbot on the Brown Ridges was 17¼ in. long, the smallest brill 16¼. Off the German coast, in June, numbers of brill and turbot, 11 to 14 in. long, were taken, and one turbot taken was only 8½ in. Sometimes 29 per cent. of the number taken were under 12 in., and, of course, quite immature.

Soles. The smallest sole caught off the German coast was 9⅞ in. long, on the Brown Ridges 8¼ in. In both cases a large proportion of the soles were adult, and of fair size.

Lemon Soles absent on both grounds.

Dabs. In both cases numbers of dabs, both small and large, were captured, and the larger, about 10 to 13 in., were kept for market.

Haddock. Absent on the Brown Ridges, few small on the northern ground, but some larger. These were less abundant than the plaice, and decreased towards the land and the shallower water.

Cod. Absent on the Brown Ridges, scarce on the German coast.

Whiting. Numbers about 13 in. long on both grounds, but only saved from the last hauls of the voyage.

Latchets. A considerable number taken on both grounds, and mostly mature and of large size.

Gurnards. Grey abundant on both grounds, red (*cuculus*) in smaller numbers.

Weevers (Trachinus draco and *vipera).* The abundance of these, especially of the larger species, is very characteristic of the Brown Ridges. I saw none on the German coast.

Sand-eels. I frequently found one or two of these entangled in the net on the German coast.

Some solenettes occurred on both grounds, but dragonets (*Callionymus* *lyra*) I saw only on the Brown Ridges; a few specimens of scaldbacks also occurred only on the latter ground. Scruff, in the form of Hydroids, was very scarce on both grounds. *Alcyonium*, or "teats" as the men call it, was abundant, as were starfishes and hermit-crabs, whelks, and whelk spawn. *Natica* occurred on the Brown Ridges, and its semicircular band of spawn, believed to be turbot spawn by the fishermen, on the German coast.

I examined a piece of the "moor-log" which I brought ashore, with the microscope, and saw only vegetable tissue-cells, brownish in colour. I also saw, with the naked eye, some grass-like stalks in it. It is evidently turf or peat.

I also made a study of some of the waste fish which I brought ashore. There were 105 *Trigla gurnardus*, 7 in. to 13 in. long, and I brought these chiefly to examine the very conspicuous change of coloration which takes place in this species during growth. At first sight the younger and smaller fish might be taken for a different species. They are of a uniform reddish colour, without spots, but not so bright a red as *Trigla cuculus*. The elements of coloration are the same as in the grey or older stage, namely red chromatophores, with definite outline and rounded form, yellow chromatophores less distinctly defined, black chromatophores, and small granular iridocytes, with indistinct outlines. In the older livery the red elements are diminished in comparative abundance, and all the rest increased. Iridocytes massed together with yellow pigment, but without either black or red, form bright, yellow spots, usually surrounded by a black ring, forming ocelli. Elsewhere the skin is mottled with yellow and black and grey, with red patches here and there. The intermediate stage is at 9 in. in length, in which only a few of the yellow spots are present.

I also examined the specific characters of the two species of weever. I had 15 *T. draco* 9¾ in. to 12¾ in. long, and 8 of 5 in. to 9¼ in. Of *T. vipera* I had 18 of 2 in. to 4⅜ in. in length.

A comparison of the smallest *draco* and the largest *vipera*, showed the specific characters to be perfectly constant. They are:—

(1) Greater vertical depth of body in *vipera*, especially from the angle of the jaw to the anus.

(2) Oblique lines of scales in *draco*, with yellow patches along the sides; *vipera* is silvery, without yellow spots or lines.

(3) Scales longer than broad in *draco*, broader than long in *vipera*.

(4) Two spines on front of orbit in *draco*, none in *vipera*.

(5) Second dorsal in *vipera* has 24 fin-rays; in *draco*, 30.

The herring and mackerel fishery, at Lowestoft, has a separate part of the harbour, and a separate market to itself, and is of very considerable magnitude and importance. In September there were no herrings to be caught at Lowestoft, and a large proportion of the boats were away fishing for these fish off the coast to the north of the Humber. Some boats were catching mackerel at Lowestoft during this month. I several times opened the stomach of mackerel to see what the food was, and only twice found anything except a little white chyme. In both these cases the tail and backbone of a fish were present, and belonged apparently to a clupeoid: very probably they were feeding on sprats. I saw no Copepods or other Crustaceans in any of the stomachs. Up to the date of my departure from Lowestoft—October 22nd, the herrings, though full, had not begun to spawn.

III. Causes of the Observed Distribution of Fish in the North Sea.

As my paper in the previous number indicates, my interest in these investigations was chiefly excited by the fact that no satisfactory explanation appeared to have been discovered for the remarkable abundance of small plaice in the German Bight of the North Sea. The explanation suggested, and held by many to be sufficient, was that there was a current from west to east which carried floating or buoyant objects towards the German shores, and that, therefore, the buoyant eggs and larvæ of the plaice were carried thither in great numbers. Dr. Fulton* has recently made direct experiments on the course of the drift, by putting floating bottles into the sea in the neighbourhood of the Firth of Forth. In certain cases, out of groups of bottles put overboard at the same spot, some were afterwards found on the English Coast to the south, and others on the coast of Schleswig and the Island of Heligoland. The course thus determined for the general circulation would probably cause more of the plaice spawn, shed in the North Sea, to be conveyed to the German and Danish Coasts than to English. But the difficulty that perplexed me was that the peculiarity of the German grounds seemed to consist not in the greater numbers of plaice generally, but in the exclusive occurrence of small plaice at distances from land at which, on the opposite English Coast, large mature plaice seemed also to occur with the small.

It is not certain that this difficulty exists; if it does exist at all, it is not to be explained by the suggestion that the plaice of the German Bight are a smaller race. The smaller race, similar in the size at which maturity is attained to the Channel plaice studied at Plymouth, exists on the Dutch coast as far as the Texel, and extends to a distance of 50 miles from that coast.

---

* Thirteenth Annual Report of the Scottish Fishery Board, 1895.

The character of the plaice in the intermediate region from the Texel to Nordeney has not been examined, and the limit of the smaller race cannot be exactly stated. It is more probable that there is a transition from one race to the other than a definite boundary between the two.

It is important, as well as interesting, to notice that other biological features of the English Channel, as well as the small size of its plaice, are found to extend into the North Sea along the Dutch coast, and some of these extend as far as the German Bight, although the plaice there are *not* similar to those of the Channel. I am referring here to the fact that certain southern fishes which are found in the Channel, are also found along the Continental coast as far as the neighbourhood of Heligoland. The first of these to be mentioned is the anchovy. The history and migration of this fish has been repeatedly discussed in previous numbers of the Journal, and it has been often mentioned that there is a regular fishery for anchovies in summer in the great Dutch estuaries, namely, the Schelde and the Zuyder Zee. Dr. Ehrenbaum on one occasion found the eggs of the anchovy in abundance in the open sea farther east, near the Island of Nordeney. On the East Coast of England the anchovy occurs but rarely, and in very small numbers, except in the Straits of Dover. The second case is that of *Trigla hirundo*, called by the east coast fishermen the latchet, by Plymouth men the tub. My records show how constantly this fish is taken in the trawl, both on the Brown Ridges and in the German Bight, as far north as the Horn Reef, while on the English side it is seldom taken. The third case is that of the mackerel. Mackerel fishing takes place off Lowestoft in May and June, and again in September and October. South of the Horn Reef, in May, we took several large mackerel in the trawl, but I believe there is no regular fishery for mackerel in that neighbourhood. Mackerel are usually found in summer in the Moray Firth, but there is no fishery for them between that region and the Wash.

It would be interesting to discuss fully the relation between the biological facts here described, and the physical conditions in different parts of the North Sea. A series of careful physical observations has been carried out recently, according to an international scheme, in which Britain and Denmark, Germany, Sweden, and Norway have co-operated, the initiative in Britain having been due to the Scottish Fishery Board. The investigation of the channels connecting the North Sea with the Norwegian Ocean and Atlantic have been described by Mr. H. N. Dickson, and a paper on the observations in the more southern parts was read before the British Association last year. But these latter observations have not yet been published in full, and therefore their consideration in relation to the present subject must be deferred. A few general facts may, however, be mentioned. The movement of floating objects, which Dr. Fulton found to occur in his experiments, is in accordance with the fact previously accepted that there is a current to the southward along the east coast of Britain, and another to the north-east from the English Channel along the Continental coast. The meeting of these two currents would necessarily cause a current across the North Sea, from the east coast of England, in a curve towards the Heligoland Bight. This movement, carrying with it the pelagic eggs and larvæ, is probably a very important factor in the explanation of the abundance of young plaice, soles, turbot, and brill in the Eastern Grounds, and generally along the Dutch and German coasts. The northward movement of Channel water along the Continental coast is also probably, in great measure, the cause of the extension of the range of the anchovy, latchet, and mackerel in that direction. But there are details which require further consideration. The anchovy, mackerel, and latchet clearly migrate towards the Dutch and German Coasts only in summer, and we know in a general way that along those coasts the summer temperature of the shallow waters is considerably higher than in the northern and western parts of the North Sea. But in winter the sea temperature along the Continental coast is lower than on the English coast; and although this agrees with the retreat of the migratory fish in winter, we cannot say how it affects the plaice, which appears to migrate very little, except from the shore to deeper water, as it grows larger. Another peculiarity of the water along the Continental coast is its lower salinity, due to the quantity of fresh water poured out by the great Continental rivers, and this may be one of the favourable conditions to which the abundance of plaice, soles, turbot, and brill, especially in their young state, is due.

A brief discussion of the growth and ages of the fish decribed in the present communication may not be without interest, and is inevitably suggested by the perusal of the memoir on the flat-fish of Denmark, recently published by the Danish investigator, Dr. C. G. Joh. Petersen.* According to the observations described in that memoir, it is possible, by measuring large numbers of plaice of all the sizes in existence at the same time of the year, to distinguish the broods of successive years, or, in other words, the fish of ages differing by one year. At certain lengths there are larger numbers of individuals than at intermediate lengths, these lengths being, of course, those of the *majority* of plaice derived from successive spawning seasons. In fact, as the production of new plaice is not constant, but confined to a particular part of the year, the spawning season, it naturally follows that if sufficiently numerous measurements are made, the waves of production ought to be perceptible in the greater abundance of plaice at certain sizes, separated by regular intervals, each group thus distinguished representing the progeny of a single year.

---

* *Report of the Danish Biological Station*, iv. 1893, published 1894. [An abstract of this Report, prepared by Mr. F. B. Stead, will be found on page 213 of the present number of this Journal.—Ed.]

It is better, when possible, to consider only the female sex in applying this method, because the sexes of the same age are of different sizes. The length at which the maximum number of specimens is found, in the sample from off Amrum on December 20th, is 13 in., while in the sample from off Nordeney in November, the corresponding length is between 11 and 12 in. Now we have not samples of all the other plaice in the same region at the same time, but we know that there were smaller, younger plaice nearer shore, and larger further seaward, and may reasonably consider the above to be the mid-size of the plaice which were completing their second year, which would be two years old in the following spawning season, about February. This conclusion is supported by the fact that they were all immature.

I am obliged to confess that I cannot altogether follow Petersen's arguments. He gives in his tables two samples taken in the Limfjord in the beginning of December, the mid-size of one being 14 in., of the other 12 in. to 12½ in. He takes 14 in. as the mid-size of what he calls group 2 from these samples, by which he apparently means that they are at the end of their third year. In my judgment, these fish closely resemble those I have examined from the German Bight, their mid-size is clearly about 13 in., and there is no reason to suppose that they are completing their third year. I consider them to be just at the end of their second year.

Petersen places the mid-size of his 2 group in the Limfjord, in July, at 10 in., of his 1 group at 5½ in., meaning by the former, plaice two years and some months old, by the latter those of one year and some months. I cannot see what reason he has for placing the middle of the 2 group at 10 in., as the largest number of specimens in his sample is at 9 in. With regard, then, to the larger northern race of North Sea plaice, there is a very distinct difference of opinion between myself and Dr. Petersen, which is most clearly exhibited in our conclusions concerning the 0 and 1 groups, that is of fish in their first summer and their second. Dr. Petersen criticises my observations in a note on p. 23 of his memoir, and there entirely ignores the fact that though I have not exhibited my data by the graphic method in tables quite similar to his, yet I have used the principle of the mid-size in separating the groups. It is true that I did not attempt to apply this principle to any extent to the 2 and 3 groups, but

I used it in distinguishing the 0 and 1 groups of plaice before Petersen had published anything concerning the growth of this species. Thus, Petersen says that my specimens in January, April, and May are explained by me as the fry of the year, but that they are the smallest specimens of a group reaching to 2, 3, 4, and 5 inches in length. Now a reference to my data on p. 347, Vol. II. of this Journal, will show that the greatest number of my specimens from the Humber at the end of April were 2 in. in length, while those of 3 and 4 inches were in very small numbers. I find it impossible to believe that these large numbers of plaice at 2 in. were over a year old, while the few of 3 and 4 inches were regarded by me as the smallest of the brood of the previous year. Petersen accepts my identification of the specimens mostly 2½ in. long in June as belonging to the 0 group, though he says they were about 1½ in. long, which is not correct. As to the absence of such specimens in May, which Petersen thinks supports his view, it was merely due to the fact that Mr. Holt did not collect any in that month.

With regard to the 1 group, or specimens in their second summer, Petersen considers that the specimens I assigned to this group, 8 to 12 in. long, from Arlberg (which he quotes as Esbjerg, Arlberg being apparently a misnomer) were over 2 years old. In his tables the 1 group in the Cattegat, in May and June, are only 3 to 5 inches long. The fish in the Cattegat appear to be considerably smaller than in the North Sea, and I certainly still believe my own estimates to be correct for the sizes at which the greatest number of individuals are found. Thus, in March, at the mouth of the Humber, the majority of plaice taken by the shrimp trawls were 7 to 8 in. long, and as far as the evidence goes the number of specimens between this and 2 in. are comparatively fewer. In May and June the mid-size of the fish brought from Schiermonnikoog and the Danish coast to Grimsby, is 9 or 9½ in. If the fish in their second year were mostly 4 or 5 in. long in summer, these fish would necessarily be more numerous than those of 8 or 9 in. long, a supposition which is against all the evidence we have at present.

Petersen states that he marked 1000 specimens of plaice in the Limfjord, 7 to 10 in. long, in March and April, 1893, and they were from 13 to 14 in. long in October and November. They grew, therefore, 4 to 6 in. in length in 6 to 8 months, and yet he believes that at 7 to 10 in. they were 2 years old. It is certain that fish grow slower as they get older, so that it is almost impossible to believe that a plaice which could grow from, say, 8 to 13 in. in 7 months, should require 2 years to reach the length of 8 in.

I think, then, that we have very strong evidence that the smaller fish, taken in spring and summer, near the German and Danish shores, and from 7 to 10 in. long are year-old fish, and that if we were to search for specimens less than 7 in. long at that time we should find them to be in smaller numbers.

With regard to the plaice from the Brown Ridges, there is considerable difficulty in forming a judgment concerning the age. We know that some flounders, and, doubtless, some plaice, spawn when they are two years old, but only a small proportion. The mid-size in the first sample is 12 in., and it is improbable that so many immature specimens of this size should be three years old, *i.e.* (the date is October), near the end of their third year. I can only suggest that we have groups 1 and 2 here mixed, that is, plaice nearly 2 and nearly 3 years old, as well as a few which are older.

The plaice from the Leman Shoal, and from off Lowestoft, present the same problem—we have evidently the same stages, only from a larger race of fish. We have the fish nearly 2 years old, those nearly 3 years, and some few older. The mature specimens belong to the last two groups.

With regard to turbot and brill, we can scarcely suppose that the former reaches the size of 14 in., and the latter 12 in., in one year. These are the mid-sizes of the immature females taken on the German grounds in June, and are, in all probability, the 2 year old fish. The year old fish, in the case of brill, probably 7 or 8 in., of turbot 9 or 10 in., would be found closer to the shore. Here, again, I differ from Dr. Petersen, who took large numbers of turbot, the mid-size of which was 9½ in., in June and July, at Bornholm, and considers them to be 2 years old. It is true the size of the turbot may be much reduced at this island, which is far within the Baltic, but, on the other hand, Petersen found similar specimens, which he also takes to be 2 years old, in the most northern parts of the Cattegat, and he has no specimens, except one or two at 4 to 6 in., which he can assign to the year-old group. Of brill, Petersen places the 2 year old size at 10 in., the year-old at 5 to 7 in., in the Cattegat.

IV.—PROPOSED RESTRICTIONS ON THE LANDING OF UNDERSIZED PLAICE, IN THE LIGHT OF THE NEW EVIDENCE.

Before the Parliamentary Committee, which conducted an inquiry in 1893, the trawling industry of Lowestoft, as represented by Mr. J. W. Hame, strongly opposed any restrictions being enforced as to the size of fish landed. One of the reasons given was that restriction was unnecessary, because small fish, especially plaice, were not landed at that port. Mr. Hame told the Committee that the day before he gave his evidence, namely, on May 10th, he turned out two boxes of plaice caught towards the Dutch coast, perhaps from 30 to 40 miles off that coast. He said that one box contained 110 fish, the smallest 12 in. long, and the other contained 90 fish, the smallest 13 in. long. These statements are quite at variance with my observations made at Lowestoft, during September and October this year, and I cannot help thinking that Mr. Hame was mistaken as to the grounds from which the fish came, or else was not sufficiently accurate in his numbers and measurements. The facts show that, on the one hand, a size-limit of 8 in. for plaice, as proposed by the Parliamentary Committee, would make no appreciable difference to the deep-sea trawling industry at Lowestoft, and, on the other hand, that higher limits, such as that which was proposed by Mr. Holt for the protection of the German grounds, would affect that port very seriously.

Mr. Holt's latest proposal was to enforce a limit of 13 in. from March 14th to September 30th, and he supported this proposal by the following contentions: That he had shown the proportion of plaice under 13 in. on the off-shore grounds of the North Sea to be inconsiderable, and that this limit, and no lower limit, would make it unprofitable to trawlers to fish on the Eastern Grounds. Now, it is necessary to see how this limit would work in the southern part of the North Sea, whose conditions I have described, and how it would affect the trawling industry at Lowestoft and Yarmouth. It is clear that the limit would stop the trawling on the Brown Ridges, and all the grounds along the Dutch coast south of the Texel to a distance of about 50 miles from the shore. In the box from the Brown Ridges, examined on October 2nd, no less than 140 out of 176, or over 79 per cent., were less than 13 in. long. In the box from the Dutch coast, received on November 18th, only 18 out of the whole 197, or not quite 8 per cent., were over 13 in. The Yarmouth and Lowestoft trawlers would have to work, therefore, on the English side, from the Outer Dowsing southwards, and, even there, would have to throw overboard a considerable proportion of the plaice now brought to market. In the box from the Leman Shoal, examined on October 4th, 47 out of 115, or 40 per cent. of the plaice, were under 13 in. In the box received on December 23rd, 83 out of 132, or 62 per cent., were under 13 in.

It can easily be inferred from these figures how the establishment of a size-limit of 13 in. for plaice would be received at Lowestoft and Yarmouth. If the regulation were rigidly enforced, it would entail the bankruptcy of probably the greater number of the smack owners, for it is not probable that the increase in the price at which the larger plaice could be sold would be sufficient to compensate for the loss of the smaller.

On the more northern grounds, which are worked by the Grimsby and Hull boats, the proportion of plaice below 13 in. is certainly smaller. Mr. Holt estimated it at 10 per cent., and he was well aware that his proposed limit of 13 in. involved the rejection of this proportion. But the evidence I have collected shows that the proportion is often higher than this. In the sample from the Dogger Bank, of which the measurements are given above, the proportion is 35 per cent., and the samples I described in my paper in the previous number show that a considerable number of plaice of 10, 11, and 12 in. are landed from the Dogger Bank, and, in fact, from all grounds less than 30 fms. in depth in summer.

It is perfectly true, as Mr. Holt pointed out, that the enforcement of a size limit of 13 in. would prevent English trawlers from fishing on the German coast in summer, and so prevent the great destruction of small plaice which they carry on. But with regard to the fishing on these grounds by German boats, I have received from Herr Düge the following important information, which will be of some assistance in forming an opinion concerning the result of keeping English vessels away, supposing the restriction to be put into operation only in Britain.

Sixty-three steam trawlers fish out of Geestemünde, and 600 to 700 sailing boats go there annually, from harbours on the Elbe. The steamers fish the whole year. The grounds worked in the different months are:

January: east and north-west sides of Dogger Bank.
February and March: Great Fisher Bank.
April: Horn Reef.
May: Horn Reef, and grounds twenty miles from East Frisian coasts.
June and July: Horn Reef and Skager Rack.
August and September: Mud-bank to the north of Heligoland, and the east and north-east sides of the Dogger Bank.
October: Mud-bank, Horn Reef, and Sylt ground.
November and December: Horn Reef, Sylt, and Jutland outer ground.

The German steamers seldom go west of 3° east longitude from Greenwich. The grounds off the Horn Reef, and the bank to the north of Heligoland, are much fished, those directly adjoining the coast less.

The sailing boats, on the other hand, fish from March to October almost exclusively within the distance of 3 to 30 miles from the East Frisian and Schleswig-Holstein coasts, and seldom go west of Terschelling, or north of Fanö. The reason of this is that the steamers fish mostly for haddock and cod, while the sailing boats seek for plaice and soles, and take the former to market alive.

There is nothing in this to show what proportion of the smallest fish on these grounds are taken to market, and it is probably true, as Mr. Holt believed, that there is a better market for the smallest plaice at Grimsby, Hull, and London, than in continental ports. At the same time, there can be no doubt that the German steamers, when they are on the small plaice grounds, must destroy as many small plaice as the English vessels, whether they throw them overboard, or take them to market, and with regard to the sailing boats, although they probably throw overboard the smallest plaice without killing them, I cannot believe that they do not take to market the plaice of 10, 11, and 12 inches, which, under the proposed regulation, English vessels would not be allowed to take. In fact, there can be no doubt that the German sailing boats depend for their maintenance and profit chiefly on the same fish as those which were brought to market by the *John Bull*, in the trip on which I was on board of her, namely, on plaice 10 to 13 inches long, soles, and small turbot and brill.

It may be admitted that it would be desirable, if it were possible, to protect and leave alive in the sea the plaice under 13 in. long. It would be desirable for two reasons—firstly, because the fish so preserved would be able to spawn, and secondly, because they would grow to a larger size, and be, therefore, more valuable in the market. According to the evidence I have given in the German Bight, the plaice below this limit are almost all actually immature, both males and females, and even on the Brown Ridges the majority of the females are immature. But we have to consider whether it would be practicable to carry out a prohibition of the landing and sale of plaice under 13 in. I have shown that such a prohibition would mean the closing of the grounds along the Dutch coast to a distance of nearly 50 miles. It must be borne in mind also that my evidence proves that a large proportion of plaice under 13 in., and still more of sexually immature fish, are taken on all grounds less than 30 fathoms in depth, which means a very large portion of the North Sea.

It would not be feasible to have one limit at Grimsby, and another at Lowestoft; the fact that fish from the Humber fleets, and from the Yarmouth fleet, which latter fishes the same grounds as the Lowestoft boats, are alike landed in London, shows how absurd the suggestion is. We have, then, the horns of a dilemma: a 13 in. limit cannot be applied to the grounds between Norfolk and Suffolk, and the Dutch coast, and no lower limit will keep the Humber trawlers from the small plaice grounds of the German Bight. We must then consider whether we are to disapprove of a size limit altogether, or to advocate a lower limit. It is clear that the imposition of an 8 in. limit would do little or no good. It is also certain that plaice of 11 in. and 12 in. form a large proportion of those landed at Lowestoft. A higher limit than 11 in. does not seem practicable, and the question is, would that limit do any good? The difficulty, of course, is that which has so often been mentioned, that the fish would be usually dead when thrown overboard, and a limit to do good must prevent fishing on grounds where the small plaice abound. In the voyage of the s.s. *John Bull*, on the grounds to the north of Heligoland, plaice below 10 in. actually were thrown overboard, and as I saw myself, mostly dead. Nevertheless, vessels are often tempted to go near shore and fill their holds with such small plaice, when there are not enough larger plaice, soles, and other fish to make a profitable cargo. A limit of 11 in. would, I believe, be of distinct benefit in preventing such a practice. Unfortunately, as I mentioned in the account of my cruise on the *John Bull*, on the Eastern Grounds soles are usually more plentiful, where the plaice are smallest, and I do not see how to prevent vessels fishing for the soles and throwing the plaice overboard. Some of the plaice thrown overboard certainly live to grow larger.

The limit of 11 in. would have certain distinct advantages in addition to the above. It would prevent almost entirely the capture of small plaice below this size, which goes on in English territorial waters by small boats, and where it is not advisable to stop shrimp or inshore trawling altogether, plaice below the limit could be returned to the water alive. In my previous paper I suggested a limit of 10 in., and still believe that even that limit would be of some benefit, but after collecting more extensive evidence and further considering the matter, I have come to the conclusion that a limit of 11 in. would be both practicable and beneficial for the North Sea, and could be applied with equal benefit and no greater difficulty to the South Coast. As a limit of 10 in. is already in force in Denmark, it ought to be possible, in time, for all the nations interested to agree to adopt the same limit of 11 or 10 in. for plaice.

There is probably more chance of soles surviving, if thrown overboard, than of plaice.

The evidence shows that there is no such wholesale destruction of small soles in extra-territorial waters, as of plaice on the German grounds, but a considerable number of a length of 8 in. or less are captured and taken to market in territorial waters, as shown above at Lowestoft. The limit of 8 in. is not sufficiently above the limit of saleability to be of much benefit, while a limit of 12 in. would be unduly high. A limit of 10 in. would be beneficial.

There can be no doubt that the capture of such large numbers of undersized turbot and brill on the German grounds is extremely wasteful, and prejudicial to the general supply of larger fish. Such undersized and immature fish of these kinds were not found on the Brown Ridges or other grounds worked by Lowestoft trawlers, but doubtless occur near the Dutch coast. There is no evidence that they occur on any grounds at a considerable distance from the shore. The reasonable and practicable limit for brill, in my opinion, is 13 in.; 12 in., as recommended by the Protection Association, would not afford enough protection on the Eastern Grounds, and the 10 in. limit proposed by the Parliamentary Committee would be of very little use.

There can be no doubt that the limit for turbot ought to be higher than that for brill, and the practicable limit, in my opinion, is 15 in. It is certain that there are no mature females below that size, and that limit would not cause any difficulty to the fishermen, except on the Eastern Grounds, or other shallow inshore waters. I have already shown the important contrast in the size of the plaice caught in the two voyages to the Eastern Grounds, described in the previous number. The same contrast presents itself in the size of the turbot and brill. The smallest turbot seen, in the first voyage south of the Horn Reef, was an immature female 13 in. long; the others were seven mature males 14 in. to 22 in., and six mature females 24 in. to 30 in. Of the brill examined three were immature females, 12 in. to 15 in.; the others were eight mature females, 13 in. to 21 in. In the second voyage, on the other hand, when we fished nearer to the land, numbers of brill and turbot under 12 in. were taken.

A Carcinus with a right-handed walking-leg on the left side of the abdomen.

PRELIMINARY NOTE.

By

Albrecht Bethe.

AMONGST a great number of crabs collected in Plymouth Sound for my studies of the central nervous system, one specimen was found with a very interesting abnormality. The thorax of the crab—a female—is normal. The length of the carapace is 47 mm., the breadth 64 mm. The claws and legs are in the right positions, and of normal proportions, with the exception of the fourth leg on the left side, which is smaller than usual. In my opinion, this leg was broken some time before the crab came in, and was not yet quite regenerated. The first four segments of the abdomen are also normal. Each has a couple of *pedes spurii*. To the fifth segment, which in the crab is always legless, a large leg is fastened on the left side. (Fig. 1.)

This leg is, as one can see at a glance, a real walking-leg, and, what may at first sight seem strange, not a left-handed, but a right-handed leg. Comparing it with the other walking-legs, one can see that this additional leg corresponds to the second and third of the thorax. Not only are the positions of the hairs and little pits the same as in those legs, but also the proportions between the single joints and the angles which form the axes of the joints.

Owing to the pressure of the large leg, the left side of the fifth abdominal segment is a little bent on both sides, and the exopodite of the left *pes spurius* of the fourth segment is stunted, so that it is not half as long as the exopodite of the other side. When alive, the leg was motionless, but it was sensitive.

When first I saw the crab, I imagined this surplus leg must be innervated by a nerve coming from a surplus half-ganglion of the right side. And this indeed proved to be the case. A dissection made from the back showed a big nerve entering the leg, and starting from the right side of the ventral cord. But, strange to say, the nerve does not leave the ventral cord at its side, but in the middle, passing through the middle hole. I cut thick frontal sections of the ventral cord. They show a small surplus half-ganglion on the right side, between the claw-ganglion and the ganglion of the first walking-leg, and not, as was to be expected, between the first and second or the second and third leg-ganglion.

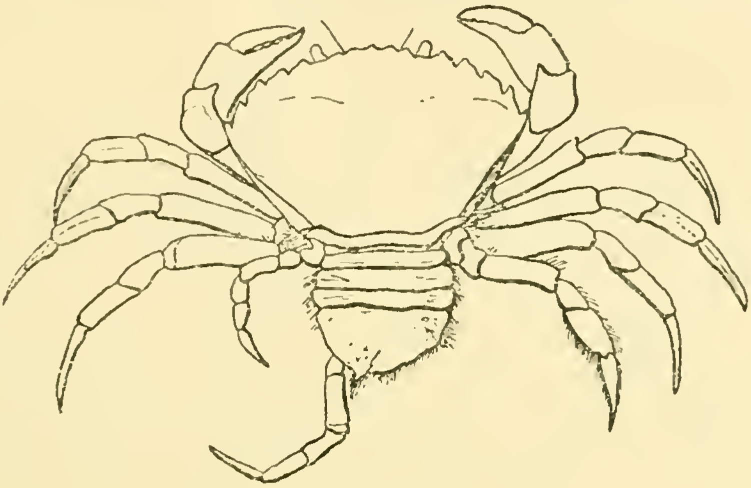


FIG. 1.

There is no doubt that in this case we have neither a double-monster nor an atavism, because the ancestors of the Brachyura never had walking-legs on the abdomen.

A second paper on this subject, containing minute descriptions and several illustrations, will soon be published in a German journal, and in that I will endeavour to give a theoretical explanation of this abnormality.

Notes on Plymouth Hydroids.

By

C. C. Nutting.

Professor of Systematic Zoology in the University of Iowa.

THE following notes are based upon observations made during April and the first half of May, 1895. Although the *Plumularidæ* were the special objects of study, a number of facts concerning other forms were noticed, which, together with the discussion of certain matters brought out in the special study of the *Plumularidæ*, were considered by the Director to be of sufficient interest for publication in this Journal. It will be understood that no general discussion of the hydroids at Plymouth is attempted, nor is it my purpose to give a list of the hydroid forms of that exceedingly rich field, no species being mentioned unless some new fact has been observed concerning it.

EUDENDRIUM ALBUM, n. sp.*

Habitat. On stones in shallow water near Millbay Channel. The stones are often covered with a dense growth of this hydroid, which appears to the unaided eye like white cottony tufts or downy patches. The gonophores were abundant in April.

The distinguishing features of this species are the minuteness of the colony and of the individual hydranths, both of which are less than half the height of any other Eudendrium from British waters, and the very striking white colour of the hydranths, a feature not found in any other Eudendrium in that locality. *Eudendrium album* is one of the most abundant hydroids at Plymouth during the spring, where it has heretofore been regarded as *Eudendrium capillare*, Alder. It seemed, however, so different from the descriptions and figures of that species given by Alder, Hincks, and Allman, that specimens were sent to the veteran authority on hydroids—Professor Allman—who regarded it as probably new, and advised the writer to describe it as such.

---

* This is the species referred to by ALLEN, vol. iv. no. 1, p. 49, of this Journal. A full description, with figures, will shortly be published in *Ann. and Mag. Nat. Hist.*

Clytea johnstoni, *Alder.* Medusæ of this species were produced in the aquaria in May.

Obelia geniculata, *Linn.* Numbers of the medusæ of this species were bred in the tanks and bottles of the Laboratory during the latter part of April. They may be readily distinguished from the medusæ of *Obelia dichotoma,* which is very abundant at Plymouth, by the fact that the former have 24 marginal tentacles, while the latter has but 16 at the time of liberation. These small medusæ are readily preserved with the tentacles well expanded by stupefying with cocaine and passing through three or four grades of alcohol.

Obelia longissima, *Pallas?* A specimen brought to the Laboratory early in April is referred with some doubt to this species, which it closely resembled in all respects, except in the fact that the hydrothecæ were marked with regular longitudinal flutings, the ridges between the adjacent hollows terminating in blunt teeth at the margin. This beautiful ornamentation was quite constant in the hydrothecæ, and formed so striking a feature as to suggest a new species. The close agreement, however, of the specimen with Hincks' description and figures of *O. longissima,* taken together with the great delicacy of the hydrothecæ of the latter, render it probable that the form under consideration was *O. longissima,* with the delicate hydrothecæ shrunken so as to be thrown into longitudinal flutings. The gonosome was not present.

Secured in Millbay Channel from a depth of about eighteen fathoms.

Campanularia neglecta, *Alder.* This very minute Campanularian was found growing on the stems of *Tubularia indivisa.* There were several gonangia present, but the acrocysts were not developed. So far as I can ascertain, *C. neglecta* has not been reported from Plymouth by previous observers, probably having been overlooked on account of its small size. It is only occasionally that the bimucronate ornamentation of the margin can be made out. The stem in its manner of branching and flexuose habit resembles a miniature *C. flexuosa.*

Campanularia flexuosa, *Hincks.* This beautiful species was found with gonosome well developed, on May 1st. The gonangia differed from Hincks' description in being ornamented with shallow but regular annulations throughout their length. At first glance no indication of this annulation is seen, but with proper treatment of light the markings are plainly made out, and appear to be as symmetrical as those so beautifully shown in the gonangia of *Clytea Johnstoni.*

Campanularia fragilis, *Hincks.* Not before reported from Plymouth. The single specimen secured from the rocks near Millbay Channel was destitute of gonosome, but showed the characteristic tubular plain-rimmed hydrothecæ of the species. The hydranths have about twenty tentacles, and the proboscis is ovate in outline when the hydranth is expanded, thus differing from most of the *Campanularidæ.*

GONOTHYRÆA LOVÈNI, *Allman.* This is one of the most abundant species at Plymouth. A number of specimens of the genus that were brought in from time to time during April and May differed so materially from *G. lovèni,* and agreed so closely with the descriptions of *G. hyalina,* Hincks, that I regarded them as belonging to the latter species, and had so labelled them, when another batch of specimens was brought in which showed completely intergrading forms joining the typical *G. lovèni* with almost typical *G. hyalina.* There is a strong probability that these two so-called species are but varieties of one form, which should bear the name of *G. lovèni,* Allman.

OPERCULARELLA LACERATA, *Johnston.* Found growing on young stems of *Tubularia indivisa* from Millbay rocks, on April 26th. Other specimens were creeping over the stems of Eudendrium. This is, I believe, the first recorded occurrence of the species at Plymouth.

OPERCULARELLA HISPIDA, n. sp.*

This species bears some resemblance to *Calycella syringa,* Linn., from which it differs in having a much shorter pedicel, a not strictly tubular hydrotheca, a greater number of segments to the operculum, in the absence of the tubular extension of the operculum, and in a much thinner structure, the hydrothecæ being of glassy transparency in *O. hispida,* but of a decided brownish or yellowish horn colour in *C. syringa.* The most striking feature, however, of the present species is the remarkably hispid appearance of the tentacles, which appear to be made up of series of triangular segments on account of the formidable array of large nematocysts with which they are armed. While examining the expanded tentacles with a ⅛ objective, I was so fortunate as to see these batteries of projectiles suddenly explode, sending out a perfect maze of barbed threads, which appeared to be larger and longer than those of any hydroid that I have seen, except *Nematophorus grandis,* Clarke.

In the absence of the gonosome, it is impossible to say with any certainty to which genus this interesting little species belongs. The general form of the hydrotheca, the cylindrical hydranth with conical proboscis, together with the convergent teeth, give a facies like that of the genus *Opercularella,* in which it is provisionally placed.

CALYCELLA SYRINGA, *Linn.* Found growing abundantly on young stems of *Tubularia indivisa.* The pedicels are often much longer than one would judge from Hincks' figure. The mass of root-stalks from this species running along in approximately parallel lines on the host, and giving off the peduncled hydrothecæ, afford a good idea of how the fascicled stems of hydroids may have arisen. In some of the specimens the aggregation of root-stalks would doubtless be sufficiently rigid to support themselves in an erect position after the stem to which they cling had died, and we should then have a loosely put together, fascicled stem, which a little further differentiation would convert into a typical polysiphonic hydrocaulus.

---

* A detailed description, with figures, will appear in the *Ann. and Mag. Nat. Hist.*

The tubular extension of the hydrothecæ reminds one of similar structures in the genus *Cryptolaria*, which contains several species further related to the one under discussion, in having the operculum composed of convergent segments.

CUSPIDELLA GRANDIS, *Hincks*. In looking over my Plymouth series of hydroids after returning to America, I found specimens of this species growing over the stems of *Halecium tenellum*. A careful examination of the stems of the larger hydroids is frequently repaid by the discovery of one or more species of minute parasitic forms which escape the casual observer, and it is quite likely that a number of new species would reward the patience of any one who would devote himself for a time to a search for these forms on British coasts.

HALECIUM TENELLUM, *Hincks*. A number of colonies with female gonangia were taken from a depth of 18 fathoms on April 19th. These specimens closely resemble in several points miniature colonies of *H. labrosum*, Alder, especially in the shape of the gonangia and the wrinkled appearance of the stems, which, however, are monosiphonic. Indeed, one cannot wonder that Alder mistook *H. tenellum* for the young of *H. labrosum*. Out of a large number of colonies of *H. tenellum* from Plymouth, there are none over half an inch in height, and they very generally show the reduplication of the margins of the hydrophores, which Hincks mentions as a characteristic feature.

PLUMULARIA PINNATA, *Linn*. This is by far the most abundant Plumularian at Plymouth, and afforded an excellent opportunity to study the morphology and reproduction of the group.

The Nematophores. There is a great deal of confusion of terms regarding these structures. The name properly applies to both the sarcodal process and the chitinous receptacle into which it retracts, although it is often used to denote either one of these structures. The terms "sarcostyle," denoting the sarcodal process, and "sarcotheca," denoting the chitinous receptacle, have now come into general use. Hincks' description of *P. pinnata* is incomplete, in that it does not notice the sarcostyles which occur without the investing sarcothecæ. One pair of these naked sarcostyles is found in the usual position of the supracalycine nematophores, and another pair is in the axil of each hydrocladium.

The structure of the nematophores has been the subject of much discussion, particularly by Hincks, Allman, Reichart, Merejkowsky, Weismann, and Jickeli. With the excellent facilities afforded by the Plymouth laboratory, and the valuable suggestions of its director, I secured a number of fortunate serial sections of the expanded sarcostyles of *P. pinnata*, and have been able to satisfy myself concerning the main points of their structure. The results of this study have corroborated the statements of Merejkowsky up to a certain point, including the following facts—

1. The greater part of the sarcostyle is composed of ectodermal cells.
2. There is a central endoderm core (or cylinder ?) *
3. The cells on one side of this core are very large and quadrangular, while the cells on the other side and of the entire terminal portion of the sarcostyle are of ordinary size.
4. There are pseudopodia-like processes from the free surface of the sarcostyle.

On the other hand, I have been entirely unable to find any trace of the "interstitial protoplasm" described by Merejkowsky, in which he claims that the ectodermal cells are imbedded. Weismann† boldly suggests that this "interstitial protoplasm" is owing to an assumed necessity for free sarcode to explain the pseudopodia-like processes on the free surfaces of the sarcostyles. It seems to me that there is no logical demand for free protoplasm to explain the great extensibility of these organs. The possible tenuity of the walls of ectoderm cells can be appreciated by any one who has made a study of nematocysts, and a careful examination of the sarcostyles, both living and in serial sections, has failed to afford any evidence of free protoplasm, and this negative result is not antagonized by any physical necessity for free protoplasm in organisms which can construct endoderm cell-walls of the marvellous tenuity and extensibility of the nematocysts.

The function of the nematophores is in more doubt than their structure, and is not yet understood. It is practically certain that they are more or less degraded "persons" of the colony which have come to subserve definite functions of great service, judging from the prevalence of these structures throughout the *Plumularidæ*. So far as the species under consideration is concerned, it is safe to say that the sarcostyles are not "fighting persons" or "machopolyps," because they are not armed with any considerable number of nematocysts, the special weapons of hydroids. An examination of the living and active sarcostyles establishes the following facts—

1. The almost incredible extensibility of these organs, which wind

---

* While at Naples, the writer was able to demonstrate that this structure, in another species, has a central cavity.

† *Die Entstehung der Sexualzellen bei den Hydromedusen*, p. 176.

around the stem, branches, hydrothecæ, and gonangia, in a perfect maze of threads, or even flattened lobate masses.

2. In retraction, the movement is not comparable to the flowing of pseudopodia, but is effected by decided, quick, jerky retraction, giving an idea of definite outlines and cohesion. To use a crude comparison, the sarcostyle contracts much as if it was made of stretched india-rubber and not of a fluid. It it also worthy of note that there is no mechanical entanglement of the various extensions of the sarcostyles, although they appear to be hopelessly intertwined.

3. The sarcostyles are particularly active in the vicinity of mutilated or dead hydranths and gonophores, particularly the latter, and seem to have a definite object in climbing over the sides and into the interior of hydrothecæ and gonangia. There is no evidence that they are able to repair damaged parts.

4. An examination of living sarcostyles, under a high magnification, disclosed certain cells on the distal surface which had the characteristic outlines and movements of amœboid cells, and contained foreign particles.

It would seem from the foregoing observations that the sarcostyles of *P. pinnata* are primarily neither fighting persons, nor persons concerned in the repair of mutilated or diseased parts. It is probable, on the other hand, that they do remove extraneous matter, or dead organic material from the interior of the hydrothecæ* and gonangia, and that they may aid in the capture and ingestion of food for the colony.

Origin of the sex-cells. This species is an excellent one for the demonstration of the cœnosarcal origin of the sex-cells in the *Plumularidæ* as first announced by Weismann.† The gonangia are so excessively numerous that a single series of sections may often be obtained which will show nearly all stages of this interesting process. The course of events in *P. pinnata* agrees very closely with Weismann's description of the origin of the sex-cells in *P. echinulata,* both ova and spermatoblasts, arising in the endoderm of the stem and afterwards migrating into the gonophores, ultimately appearing as ova, or sperm, masses in the matured structures. The ova break through the "stutzlamella" and are fertilized and undergo segmentation between the stutzlamella and the ectoderm. Although the ultimate division of the spermatoblasts may take place in the ectoderm, the primary divisions occur in the endoderm. I have been unable to find any cells recognisable as spermatoblasts in the ectoderm, although very satisfactory serial sections were made of the male gonophores. It may be, however, that my specimens were too near maturity to furnish conclusive evidence in this matter. In living specimens a division of sperm-cells with partially-developed flagella was observed in the ectoderm.

---

* E. Metschnikoff, *Quart. Jour. Micr. Sci.* no. 93.

† See *Die Enstehung der Sexualzellen bei den Hydromedusen*, by Dr. August Weismann. The first announcement was in *Zool. Anzeig.* no. 75, 1880.

Asexual multiplication of P. pinnata. On April 23rd several colonies of this species were brought in, which were peculiar in having the ends of a number of hydrocladia greatly elongated, destitute of hydrothecæ and nematophores, and distinctly clavate at the tips. Such specimens were brought in almost daily for some time, whenever the boat went out for collecting. The first colonies found were isolated and kept under observation. They rapidly increased in length, and the terminal turgescence became more prominent. In three or four days it was noticed that these enlarged ends were forking and commencing to branch.

In about a week after the first specimens were noticed, it was found that the side of the jar in which the colonies were confined was marked with closely adhering thread-like filaments, which, on examination, proved to be the greatly produced hydrocladial extensions mentioned above, and they were still connected with the colonies from which they sprung. From these adherent extensions were growing new colonies of *P. pinnata* in various stages of development.

After a time the connection between the parent colonies and the young was severed by atrophy of the connecting hydrocladial extension, rootlets were put forth from the adherent portion or end of the original hydrocladia, and thus young and perfectly independent colonies were produced which grew rapidly during the next few weeks. Another group of colonies showing the hydrocladial extensions was so placed that the extensions could not touch the sides of the bottle in which they were kept. In this case the hydrocladia grew and forked as before, and new colonies arose from the forked ends of the hydrocladia. The parent stalks afterwards died and fell to the bottom, giving the young colonies a chance to attach themselves to the glass.

This process reminds one so forcibly of the sending out of stolons from which new shoots arise, as seen in many plants, that I have proposed the name of stoloniferous reproduction for the asexual multiplication of *P. pinnata* as above described.* It is the first recorded instance of the kind among the Hydroida so far as I can find, although it bears considerable resemblance to the fissiparous formation of frustules as recorded by Allman.†

PLUMULARIA HALECIOIDES, *Alder.* This minute Plumularian was found parasitic on *Antennularia.* The gonosome was not present.

---

* See *American Naturalist*, November, 1895.

† *Gymnoblastic Hydroids*, p. 152.

PLUMULARIA ALLENI,* n. sp.

Habitat. Found growing on *Antennularia ramosa.* This delicate species bears considerable general resemblance in size, form, and parasitic habit to *P. halecioides.* It differs, however, in having a non-fascicled stem, smaller hydrothecæ, more numerous nematophores, and especially in the gonangia, which are greatly unlike the annulated structure of *P. halecioides.*

AGLAOPHENIA PLUMA, *Linn.* In studying the development of the corbulæ of this species, an interesting fact regarding the sarcostyles was noticed. A young corbula was under examination, the leaves or ribs of which had not yet coalesced, and the sarcostyles of one leaf were seen to stretch across and attach themselves to the next leaf in front, and remain for some time in that position. It appeared as if these sarcostyles served as temporary attachments to hold the edges of the two leaves together, while they were connected by trabiculæ of coenosarc, which rapidly formed a stronger and permanent connection. The perisarc of the edges of the leaves seemed exceedingly thin, and in places appeared to be wanting. A contact having been established between the edges of adjacent leaves, the permanent attachment was soon formed, and the coelomic cavities of the leaves established connections at these points. A little later, currents of water bearing granules were seen to flow in active streams from one leaf to the other. In their incipient stages it is difficult to tell the difference between sarcostyles and gonophores, and they make their appearance at about the same period in the development of the corbulæ.

AGLAOPHENIA HELLERI, *Marktanner-Turneretscher.*† This is the form collected by Mr. Allen from Eddystone Rocks, and mentioned by him on page 49, volume iv., No. 1 of this Journal. This being the first record of *A. helleri* on British shores, the following description is given for the benefit of those who may not have access to the original—

Trophosome. Colony unbranched, attaining a height of three-quarters of an inch. Stem monosiphonic, divided by very deep nodes into short internodes, each bearing a hydrocladium springing from its antero-lateral aspect. Hydrocladia alternate, closely-set, divided into internodes, each bearing a hydrotheca, and partly divided by two imperfect transverse septa. Nodes very distinct. Hydrothecæ obconic, about as deep as the aperture is wide. Marginal teeth nine, unequal in size, the anterior one often being slightly incurved, and rather longer and more pointed than the others; the second and fourth teeth, counting from behind, are larger than the first and third. There is no apparent intrathecal ridge. Supracalycine nematophores rather small, stout, reaching to the level of the hydrothecal margin; the mesial nematophore springs from just below the margin of the hydrotheca, and projects straight upward and outward, its truncated end reaching to the level of the longest marginal teeth. There are two modified nematophores on each hydrocladium near its base.

---

* Named in honour of the Director of the Plymouth Laboratory, an enthusiastic worker in marine zoology. Detailed description with figures will be published in *Ann. and Mag. Nat. Hist.*

† *Die Hydroiden des K. K. Naturhistorischen Hofmuseums*, Vienna, 1890, p. 271, plate vii.

Gonosome. (Description from Naples specimen.) Corbula thick and short, with the leaves or ribs more closely soldered together than in other small British species. Ribs six on each side, with a row of nematophores on their distal edges.

Habitat. Found growing on thick roots of marine plants taken from Eddystone Rocks.

Distribution. Naples and Rovigno (Marktanner-Turneretscher), and Plymouth, England.

A List of the Parasitic Copepoda of Fish obtained at Plymouth.

By

P. W. Bassett-Smith, F.Z.S., F.R.M.S., Surgeon, R.N.

THE material from which the present list of Parasitic Copepoda has been compiled was obtained in part by the examination of fish at the Marine Biological Association's Laboratory, but to a still greater extent by daily and diligent search at certain fishmongers' in the town. The following are the most important works consulted:—

1785. Müller, O. F., *Entomostraca seu Insecta testacea, Lipsiæ et Hafniæ.*

1826 and 1831. Otto and Burmeister, *Nova acta Natur Curios.*

1832. Nordmann, A. von, *Mikrographische Beitrage zur Naturgeschichte der wirbellosen Thiere.*

1834–40. Milne Edwards, *Histoire Naturelle des Crustacés.*

1838. Kroyer, H., *Om Snyltekrebsene isaer med Hensyn til den Danske Fauna,* Kroyer's Naturhist Tidsskrift, Bd. 2, pp. 7–52, 131–157.

1850. Baird, W., *Natural History of the British Entomostraca.* Ray Society.

1851. Beneden, P. J. Van, *Note sur un Crustacé parasite nouveau, avec l'enumeration des especes, &c.* Bull. de l'Acad. de Belg. tome xviii. 1, pp. 286–290.

1860. Claus, C., *Zur Morphologie der Copepoden.* Wurzburg naturwiss Zeits. i. pp. 20–36.

1862–68. Hesse, *Observations sur des Crustacés rares ou nouveaux des côtes de France.* 16 papers, Ann. Sci. Nat.

1865. Heller, C., *Crustaceen,* Reise der Fregatte Novara.

1866–79. Gerstäcker, A., *Crustacea,* vol. 5, Bronn. Class. und Ord. des Thierreichs, *Copepoda,* pp. 590–806.

1875. Claus, C., *Ueber die Entwickelung, Organisation und systematische Stellung der Arguliden.* Zeits wiss Zool. vol. xxv. pp. 217–224.

1875. Claus, C., *Neue Beiträge zur kenntniss der parasitischer Copepoden, nebst bemerkungen über das System derselben*, tome cit. pp. 327–360.

1877. Kurz, W., *Studien über die Familie der Lernæopodiden.* Zeit wiss Zool. vol. xxix. pp. 380–428.

1877. Vogt, C., *Recherches Cotières*, Arch. Zool. Exper. vol. vi. pp. 385–456.

The system of classification here adopted is that of Gerstæcker, which is founded largely on the minute anatomy of the animals, and is the most recent.

CALIGIDÆ.

Caligus, *Müller.*

Second and third pair of thoracic legs bifid; each branch with two joints, first and fourth not bifid. Fourth pair with elongated basal joint; cephalothorax not deeply notched in the centre, frontal lobe bearing a sucking disc near the base.

a. Abdomen long.

1. *Caligus rapax, Milne Edwards.* This species was taken in abundance on the surface of the scales of sea trout, *Salmo trutta* (with *Lepeophtheirus stromii*), in the mouth of cod, *Gadus morrhua*, and rarely on the surface of grey mullet, *Mugil capito.* Male generally found accompanying the female, but in smaller numbers.

2. *Caligus diaphanus, Nordmann and Kroyer* (not *Baird*). Found in quantity on the inner surface of the operculum of *Trigla hirundo* and *T. cuculus.* This species is very small, but agrees exactly with Kroyer's description and plate.

3. *Caligus scomberi, n. sp.** I have been unable to place this with any recorded species, and have therefore named it after the fish it is taken from. It is found on the inner surface of the operculum of *Scomber scomber.* It much resembles the last, but the carapace is oval instead of being rounded, and the abdomen is much longer.

4. *Caligus elegans* (?), *Van Beneden.* A doubtful specimen from the mouth of *Gadus morrhuæ.*

5. *Caligus (Sciænophillus) tenuis, Van Beneden.* Found on the inside of the operculum of *Sciæna umbra.* Four specimens were found, on the only fish of the kind examined, and were unmistakeable.

b. Abdomen short.

6. *Caligus minimus, Nordmann.* A number of specimens of both sexes were taken from the gill cavity and mouth of the bass, *Labrax*

---

* A description, with figures, of this and the other new species mentioned in this paper, at present in manuscript, will be published shortly elsewhere.

lupus, in June and October. The *Hamulus accessorius anterior* is particularly long, and the second maxillipedes in the male are very strong and large.

7. *Caligus Mülleri, Leach*, was found on the surface of the body of poor-cod, but was only seen on a few occasions, a large number of males being taken proportionately to the females. The same *Caligus* was also found on *Trigla gurnardus*.

8. *Caligus curtus, Müller*. This species was taken frequently from the mouth of the cod. Both the description and figure in Müller's work are very indefinite. This species differs from the latter in being rather smaller, the furcula branches longer, and the abdomen rather bigger.

9. *Caligus gurnardi, Kroyer*. One specimen of this species was taken from the gill cavity of *Trigla cuculus* in June.

10. *Caligus brevipedis, n. sp.** Two specimens of this curious form were taken, in August, from the gill cavity of *Motella tricirrata*. It differs from all other described species in the rudimentary condition of the fourth pair of thoracic limbs. The same character was found in both specimens, so that it could not well be an abnormality.

LEPEOPHTHEIRUS, *Nordmann*.

Frontal lobes without sucking discs; fourth thoracic segment free; genital segment without lobes on the back; abdomen appearing free behind.

a. Abdomen long.

1. *Lepeophtheirus stromii, Baird* (*vesper* of *Milne Edwards*). Specimens of both sexes of this species were found in quantity on the surface of the body of salmon and salmon-trout in June and July.

2. *Lepeophtheirus pollachius, n. sp.** Both sexes taken in quantity from the palate and back of the tongue of *Gadus pollachius*, also from the gills of the ling, *Molva vulgaris*. This species is nearly allied to the last mentioned.

3. *Lepeophtheirus Thompsoni, Baird*. In the gills of turbot and brill, *Rhombus maximus* and *laevis*. The specimens of this species were generally found in great numbers in the gills of the above-mentioned fish; I have taken as many as thirty from one. The specimens described by Kroyer as *L. rhombus* is closely allied in detail, but the carapace as represented by him is very small and round, whereas in this species it is large and distinctly oval, as shown by Baird.

4. *Lepeophtheirus obscurus* (?), *Baird*. Found in the gills of *Rhombus laevis* only. This species has outwardly a very close resemblance to

---

* See former note, p. 156.

the last, but the furcula is distinctly and markedly different, the branches being short, and each branch bifurcating. The male agrees with the description given by Baird of a specimen which I believe he mistook for a female. As this specimen was also taken from the brill, it is likely that they are one and the same species. I have therefore named my specimen accordingly.

b. Abdomen short.

5. *Lepeophtheirus pectoralis, Müller.* This species was very common, taken all round the year, from plaice, flounder, and dab; very frequently attached to the posterior surface of the pectoral fin, but they were often seen moving actively about over the body of newly-caught fish. Especially common on the flounder. Both sexes abundant.

ELYTROPHORA, *Gerstæcker.*

(1) All four pair of legs two-branched, the terminal branch of all provided with long plumose hairs. (2) The number of joints in each branch varying. (3) The outer and inner branch of first pair two-jointed, both branches of second and third with three joints, the inner branch of fourth with two only.

Elytrophora brachyptera, Gerstæcker. From the gills of a large tunny, *Thynnus thynnus,* taken outside Plymouth, I obtained ten specimens of this species, five of each sex, all alive. These I watched for several hours in a bell-glass. They were very active, and the males were seen to attach themselves to the females in the position represented in Dr. Heller's work, firmly fixed by the hook-like posterior antennæ, and second maxillipedes.

TREBIUS, *Kroyer.*

(1) All four pairs of legs two branched, the terminal joints of all provided with long plumose setae; (2) the outer and inner branch of the first pair with two joints, both branches of second, third, and fourth with three joints.

Trebius caudatus, Kroyer. Specimens were found on the dorsal surface of the head, and in the nasal cavities of the skate, *Raja batis,* but were not common. One was also taken from the skin of a pollack, but possibly may have found its way there during the manipulation of the fish in the boats or on the quay.

CECROPS, *Leach.*

(1) The end joints of the bifid branches of all the true legs, with short hook-like bristles, or having smooth edges; (2) front edge of the cephalothorax deeply cut, two lobed; (3) anterior antennæ covered.

Cecrops Latreillei, Leach. Two specimens were found in the gills of sunfish, *Orthagoriscus mola.*

PANDARUS, *Leach.*

(1) Front edge of cephalothorax, not deeply lobed; (2) anterior antennæ free; (3) cephalothorax broader behind than in front; (4) first pair of maxillepeds cheliform; (5) the outer branch of first true leg single-jointed, the inner with two joints, both branches of second and third pairs two jointed, branches of fourth pair one jointed.

Pandarus bicolor, Leach. A number of specimens of this species were taken from the surface of *Scyllium catulus.*

DICHELESTHINA.

LERNANTHROPUS, *Nordmann.*

(1) Abdomen without dorsal plates; (2) the two posterior pair of limbs changed into lamellar appendages; the two first pair very small.

Lernanthropus Kroyeri, Van Beneden. From only one *Labrax lupus,* in over a dozen examined, did I find any of these curious animals. This was a full-grown fish, and twelve were found, some on the gills of either side. Many of them had the abdomen as a tense bag of bloody fluid, and most had spermatophores attached.

CLAVELLA, *Oken.*

(1) Anterior antennæ single, six-jointed, projecting under the edge of the cephalothorax; (2) posterior antennæ with single hook-like claw; (3) only the anterior pair of limbs formed; (4) genital segment of female, five to six times as long as the anterior part of the body.

Clavella mulli, Van Beneden. A number of specimens of this minute species were taken from the gills of the red mullet, all females. The long straw-coloured ovarian tubes are easily seen projecting beyond the gills.

CYCNUS, *Edwards* (*Congericola, Van Beneden*).

All four pairs of limbs formed, and two branched anterior antennæ, six-jointed.

Cycnus (*Congericola*) *pallida, Van Beneden.* This species was not common. From 14 well-grown conger, I only obtained specimens in two: eleven altogether. They are, however, very difficult to find. The posterior antennæ are very strong and large, compared with the last genus.

LERNÆODEA.

PENELLA, *Oken.*

Thoracic legs close together, found just behind the head, neck without distinct segments, egg sacs thread-like, the hinder part of the body (the genital segment) joined to the neck in a straight line; from the end of the latter projects the abdomen, as a long plumose rod. Head rounded and corrugated, carrying behind it two arm-like projections.

Penella sagitta? Linn. One specimen was obtained from the Laboratory, but from what fish was not known.

LERNÆONEMA, *Milne Edwards.*

Genital segment passing gradually into the neck; head obliquely cut off, or rounded in front; genital opening placed far off from it; thoracic legs with developed oar-like joints.

1. *Lernæonema monillaris, Milne Edwards.* A very perfect specimen of this species was found attached to the sclerotic of a young herring taken in November. There was no malformation of the eyeball.

2. *Lernæonema encrasicola? Van Beneden.* A broken specimen, probably belonging to this species, was taken from a *Clupea alosa.*

LERNEA, *Linn.*

Genital segment dilated, bent in the form of an S, and twisted on its axis; head in front bearing slender forked processes; neck short, simple; all four pairs of thoracic legs unfolded.

1. *Lernea branchialis, Linnæus.* Specimens were taken from the gills of the cod, bass, whiting, haddock.

The body is always full of sanguineous fluid, and the head with its long horns, together with the neck, are deeply buried in the tissues of the gills and head, being surrounded by a laminated clot of blood encysting those parts completely. When once fixed there is apparently no power of movement. The gill cavity of a whiting would appear to be almost filled up with one of these large parasites, and they must materially interfere with the action of the gills.

2. *Lernea lusci, n. sp.** This animal was found only in the gills of whiting-pout, *Gadus luscus,* and was very common, as many as four being found on one fish. The whole head is surrounded by a clot of blood, the elongated horn being buried by the side of the gill bone.

---

* See former note, p. 156.

CHONDRACANTHINA.

CHONDRACANTHUS, *De la Roche.*

(1) Cephalothorax not separated from the abdomen by a long thin neck. (2) Front end of the body neither thicker nor more slender than the posterior part. (3) Posterior antennæ in the form of hooks. (4). Cephalothorax without processes. (5) Abdomen compressed with concave sides, or with elongated lobes. Behind the second maxillipedes are two pairs of lobed processes, representing the thoracic limbs.

(*a*) Two small horns at the posterior angles of the thorax.

1. *Chondracanthus cornutus, Müller.* A great number of specimens were taken from the gills of the Plaice, *P. platessa,* Flounder, *P. flesus,* and *P. megastoma.* They differed very much in size, being small and especially abundant in the Flounder. The male was almost invariably found fixed on the abdomen of the mature females, by means of its strong, hook-like posterior antennæ.

2. *Chondracanthus soleæ, Kroyer.* Found in the gill cavity of *Solea vulgaris,* but not common; male like the preceding.

3. *Chondracanthus clavatus, n. sp.** Found only on the gills of *P. microcephalus.*

(*b*) A number of supplementary lobes on the sides, none on the middle line.

4. *Chondracanthus triglæ, Blainville* (*C. assellina, Linn*). These were plentifully taken from *Trigla gurnardus, T. cuculus,* and *T. hirundo.* The whole anterior portion of the head, and so-called neck, is buried in a fleshy mass in the substance of the gill, the thoracic portion only showing.

5. *Chondracanthus merluccii, Holten.* Taken from the mouth of *Gadus merluccius,* and is very common; in no fair-sized hake have I ever found it absent. Great numbers are often found together, large areas of mucous membrane being destroyed. The very large hooks of attachment (the second antennæ) being deeply buried, strong muscles are inserted into the bases of these, both for abduction and adduction, so that one would gather that the animal is able to relax its hold, and probably move from place to place. The male resembles closely that of *C. cornutus;* in fact, no matter how varied the form of the female in this genus, the males are perfectly distinctive. It was also noticeable that one female would often have more than one male attached, usually to the abdomen. At times as many as five or six would be found fixed on to the various parts of the animal. Occasionally young *Caligidæ* were also present as secondary parasites.

---

* See former note, p. 156.

(*c*) Supplementary horns in the median line.

6. *Chondracanthus Zei, De la Roche* (*De la rochiana, Blainville*). Found on the gills of *Zeus faber*. This, too, is very common; one of these being usually found on either side in the anterior angle of the gill cavity. When very small, the horn-like processes are soft and crowded. Male like that of *C. cornutus*.

7. *Chondracanthus lophii, Johnst.* (*Ch. gibbosus. Kroyer*). Found in almost all well-grown angler fish, *Lophius piscatorius*, attached to the gills.

LERNÆOPODIDÆ.

LERNÆOPODA, *Kroyer*.

Cephalothorax short, not attenuated, plainly separated from the body. Maxillipedes of the second pair, long, thin, arm-like, united at their ends; Cephalothorax one-jointed, oval. Body narrow, bag-like, only slightly segmented.

1. *Lernæopoda salmonea, Linn.* (*L. carpionis, Kroyer*). One female specimen found on the gills of *Salmo salar*.

2. *Lernæopoda galei, Kroyer.* Many specimens of this animal were taken from *Mustelus vulgaris, Galeus vulgaris, Acanthias vulgaris.* They were found attached to the soft skin behind the pectoral and anal fins, more particularly in the deep folds by the anal fins of the male fish, and were frequently taken alive.

BRACHIELLA, *Cuvier*.

Cephalothorax markedly thin and elongated, often ringed like a worm. Second maxillipedes are long, arm-like, only united together at their extremity as in the preceding genus, but without articular appendages at their base as in *Tracheliastes*.

1. *Brachiella thynni, Cuv.* From one large Tunny, *Thynnus thynnus*, I obtained four specimens, attached to the soft skin, behind the pectoral fins, two on either side, two being mature and two quite small.

2. *Brachiella insidiosa, Heller.* These were found attached to the gill rays of the hake, *Gadus merluccius*, being fairly common. They agree very closely with that described by Heller (obtained from a species of *Gadus* in the Mediterranean), except that the arms are rather shorter, and the cephalothorax is more acutely bent. Both females and males were found.

3. *Brachiella impudica, Nordmann.* A number of specimens were taken from different species of Gurnards—*Trigla cuculus, T. gurnardus,* and *T. hirundo.* They were generally found attached to the soft skin on the inner side of the operculum near to the border, and were very characteristic. The male was generally found fixed

upon the back of the cephalothorax, and has been described by Milne Edwards.

Var. parva? Very frequently a smaller animal was also found on the same fish, in like positions, apparently differing only in not having any secondary lobular prolongations on the arms. They had the three pairs of horn-like processes posteriorly, and the males appeared identical; but as they bore egg sacs, they might be specifically different.

4. *Brachiella bispinosa, Nordmann.* Found in quantity from *Trigla cuculus, T. gurnardus, T. lyra.* Attached to the gill rakers of the outer branchiæ; rarely more than two on each fish. The head has the same characteristic organs as in *B. impudica.* The male, which is found at the back of the cephalothorax, has also equal resemblance.

5. *Brachiella triglæ (Anchorella triglæ, Claus).* This species is found attached to the gills of the various Gurnards, *T. cuculus, gurnardus,* and *hirundo,* but was not very common. Although in its outward form the female has most of the characteristics of an *Anchorella,* the male distinctly shows it to belong to this genus.

6. *Brachiella merluccii, n. sp.** These animals are always found attached to the *points of the gill-rakers* of the Hake, *Gadus merluccius,* and never attached to the gill rays themselves, as *B. insidiosa.* Both were frequently found in the same fish, but their positions were never other than that noted.

ANCHORELLA, *Cuvier.*

Second pair of maxillipedes short, united together, ending close to their origin, in a fixing organ. (Male showing no trace of segmentation of the body, which is not elongated, but globular. B.–S.)

1. *Anchorella emarginata, Kroyer.* This species was found attached to the gill-rakers of the outer branchiæ of *Clupea alosa.* The second pair of maxillipedes are *not* completely united at their base.

2. *Anchorella paradoxa, Van Beneden.* Found on the gills of *Scomber scomber,* but rare. The species is, however, very characteristic, and the male is distinctive, but has not yet been described by any author.*

3. *Anchorella uncinata, Müller.* This species is extremely common, being found in the folds of skin around the mouth, and in the gill-cavity of cod, haddock, pollock, whiting, and whiting-pout. The organ of adhesion of this species is a perfect drill.

4. *Anchorella quadrata, n. sp.** A few specimens were obtained of this species from the Dragonet, *Callionymus lyra,* attached to the gill rakers. This species is much like *Anchorella falax,* Heller, in form, except for the great size of the abdomen.

---

* See former note, p. 156.

Faunistic Notes.

By

E. J. Allen, B.Sc., W. Garstang, M.A., E. T. Browne, B.A.,
and T. V. Hodgson.

Notes on Dredging and Trawling Work during the latter half of 1895.—During the summer and autumn of the year 1895 it was possible, with the aid of a grant made for the purpose by the Government Grant Committee of the Royal Society, to carry on dredging work with some regularity in deeper water, and at greater distance from Plymouth Sound, than had been possible in previous years. Our efforts were concentrated upon the grounds lying between Start Point and the Eddystone, with a view to compiling a chart showing the nature of the bottom at each spot, and the animals and plants which live there. For this purpose samples were taken, as far as possible, of every species brought up by the dredge and trawl, and preserved for identification, note being made of the relative abundance of each species. With the exception of the Polyzoa and Polychætes, the material collected has now been worked over, and lists of the animals obtained at the different spots drawn up. It would not, however, be advisable to publish the full details at the present stage, as it is our intention to work the same grounds again during the first six months of 1896, at the end of which time the results of the year's work will be combined, and a detailed chart drawn up. Many conclusions, gathered from a study of the rough charts already made out, require to be checked, and others, perhaps, will require modification.

Broadly speaking, the district under investigation can be divided into three principal regions, characterized not only by the nature of the bottom, but also by the animals which live there. The first of these comprises the grounds around the Eddystone, where the bottom is, for the most part, composed of broken shell; the second, a broad stretch of sandy ground, extending from a couple of miles east of the Eddystone to a line drawn about north and south, and passing through Bolt Tail; and the third includes the off-shore grounds between Bolt Head and the Start, where gravel, broken shell, and soft rock predominate. Each of these three principal regions is, of course, capable of considerable further sub-division, but an account of these, with their inhabitants, must be postponed.

It may be well, however, to give some notes on a few of the rarer animals found, or of those which have not previously been taken by the Marine Biological Association at Plymouth.

Paraphellia expansa, Haddon. Three or four specimens of this interesting anemone were dredged, on August 16th, in about 26 fathoms, at a distance of 3 miles N. W. of the Eddystone. The surface was covered with fine particles of gravel. One of the specimens is still alive in the Laboratory. This species, for which a new genus was formed, was first obtained by Haddon at the mouth of Bantry Bay, in a depth of 40 fathoms, and was described from two specimens—one obtained in 1885, and a second in the following year.* Specimens have since been obtained by Prof. Herdman from near the Isle of Man.†

Sarcodictyon catenata, Forbes. The red variety was common on shelly grounds, both round the Eddystone and off Prawl Point.

Heterocordyle conybearei, Allman. Four colonies of this rare hydroid were dredged near the East Rutts, on August 30th. The species was identified by Mr. E. T. Browne, to whom the following note is due:—Each colony was on a large shell of *Buccinum undatum*, inhabited by the common Hermit Crab, *Eupagurus bernhardus*. The colonies correspond to the description given by Allman. There was no difficulty in identifying the species as the gonophores, each with a single ovum, were present in large numbers upon the blastostyles. This hydroid was first taken by Allman in Glengariff Harbour, Bantry Bay, and afterwards by Hincks at Oban, which are, I believe, the only localities where it has been found.

Of the other Hydroids, *Thuiaria articulata*, Pallas, and *Diphasia tamarisca*, Linn., are worthy of mention.

Ophiactis balli, Thompson, was abundant around the Eddystone, and especially so off Prawl Point. *Ophiura affinis* was also taken at the latter place, and a single specimen of *Echinocardium pennatifidum*, Norman, was dredged from a bottom of broken shell, about 5 miles south of Bolt Head.

Polygordius sp. occurred in numbers in gravel and broken shell dredged off Prawl Point (34 fms.), and a few were also taken from a ground of fine broken shell (20 fms.) south of the Eddystone.

---

* HADDON, "Revision of British Actiniæ," *Trans. Roy. Dub. Soc.* iv. (Series ii.) p. 321.

† *Brit. Assn. Report*, Ipswich, 1895.

Eupolia curta, Hubrecht. This nemertine was found on three occasions, and was identified by Mr. Riches, who had already taken a specimen in the neighbourhood. It has not previously been recorded for the Atlantic, but occurs in the Mediterranean, at Mauritius, Polynesia, and the West Coast of South America.* We have taken it in the following localities: (1) ½ mile N.W. by ½ N. of Eddystone, August 16th, ground fine broken shell (17–20 fms.); (2) Off Borough Island, August 20th, soft red rock interspersed with gravel (17 fms.); (3) 5 miles S. by E. of Prawl Point, September 17th, shells, broken shell, and gravel (34 fms.).

Dondersia banyulensis, Pruvot. (*Arch. Zool. Exper. et Gen.* ix. 1891, p. 715) = *Myzomenia banyulensis* (Simrot, "Mollusca," *Bronn. Thier-Reichs*, 1893, p. 231.) This interesting neomenian, for the identification of which I am indebted to Mr. Garstang, was taken 3 miles E. by N. of the Eddystone, on the 30th September, in 30 fathoms. Four specimens of the bright red variety were found on the hydroid *Lafoea dumosa*, var. *robusta*, growing on *Pecten* shells. The species has previously been found, also on *Lafoea dumosa*, at Banyul and Roscoff.

Lyonsia norvegica. This lamellibranch was obtained off Prawl Point. A specimen was subsequently taken off Stoke Point.

In addition to the above, which were obtained from deeper water, the following species taken in the ordinary collecting work of the Laboratory may be mentioned.

Tubiclava lucerna, Allman, growing on stones dredged from Millbay Channel (within the Sound), on November 14th. Gonophores were not present. The species is much more slender than *Tubiclava cornucopiæ*, Norman, and the corrugation of the polypary, and its dilatation at the base of the polypite, were very marked. It has previously been taken by Allman, in a rock-pool at Torquay and in Dublin Bay. It does not appear to have been since recorded.

Stylochoplana maculata, Quatrefages, was found in numbers on December 11th, crawling upon zostera dredged in Cawsand Bay. Gamble † gives the following localities for this species: Berwick Bay (Johnston); Firth of Forth (Dalyell); Firman Bay, Guernsey (Lankester); St. Andrews (McIntosh); Jersey (Koehler); St. Malo (Quatrefages); St. Vaaste-la-Hogue (Claparède). It has not been previously recorded for this district.

E. J. ALLEN.

---

* See BÜRGER. Nemertinen. *Fauna u. Flora d. Golfes v. Neapel.* 1895, where an interesting chart is given showing the distribution of the Genus *Eupolia*.

† *Quart. Jour. Micr. Sci.* xxxiv. 1892–93, p. 498.

On Doris maculata, a new species of Nudibranchiate Mollusk found at Plymouth.—Under the name *Doris maculata*, I describe a small Dorid of striking appearance, which has been several times obtained at Plymouth, and which seems to be quite distinct from any form hitherto described. Pending the appearance of a more complete account of the anatomy and affinities of this interesting form, the present note will enable naturalists to recognise its appearance, and to identify it in the event of additional specimens being found. A brief reference to this animal occurs in my "Faunistic Notes at Plymouth for 1893–94." (*Jour. Mar. Biol. Assoc.* vol. iii. 1894, p. 220.)

The notæum of *Doris maculata* is usually about twice as long as broad, the sides being approximately parallel, and the two extremities equally rounded. The body, however, is flexible, and the actual form of the animal varies accordingly at different times. The largest specimen observed was nearly one inch in length, and proportionately stout and broad; but the usual length of the specimens obtained varies from three-eighths to three-quarters of an inch.

The rhinophores are large, distinctly laminated, and completely retractile. The edge of the rhinophoral cavity is very slightly, if at all, elevated, but is usually provided with a pair of purple tubercles at its sides, one lying on the inner side, the other on the outer side of the cavity.

The circumanal gills are constantly five in number, and are so situated that one gill is anterior and median in position, two others form an antero-lateral pair, and the remaining two a postero-lateral pair, symmetrically disposed with regard to the anus. The gills are simple pinnate plumes, completely retractile within a cavity, and are held out somewhat stiffly in expansion. The peribranchial fossa is bounded by a thin raised lip, which is beset with a number of small tubercles, some of which are pigmented with purple granules.

The foot is broad, and, although concealed beneath the notæum when the animal is at rest, projects slightly behind it during locomotion. The anterior margin of the foot shows a transverse groove, which separates a slender propodial lip from the rest of the foot. The propodium is quite simple, and shews no trace of a division into two lateral halves.

On each side of the oral protuberance is an oral tentacle, whose shape is bluntly conical, or digitiform, according to its state of elongation.

The feature which gives this new *Doris* its most distinctive appearance is the presence, on the back, of a number of conspicuously coloured tubercles, connected with one another by a network of low ridges. These tubercles are of different sizes, and there is a good deal of irregularity in their arrangement. It is usually possible, however, to recognise two longitudinal rows of particularly large tubercles, three or four on each side, which extend from the rhinophores to the peribranchial fossa. These two rows of large tubercles are situated along a pair of lines which are the sites of tubercular or pigmented modifications in certain other types of *Dorididæ, e.g.* the sub-lateral rows of filaments on the back of *Idalia Leachii,* and the post-rhinophoral rows of pigment-patches in *Doris* (*Jorunna*) *Johnstoni.* In *Doris maculata* there is also an irregular median series of tubercles, as well as a number of smaller lateral tubercles irregularly scattered over the back between the main sub-lateral rows and the margin of the notæum.

The tubercles are of a deep purple colour, due to granular deposits of a purple pigment.

The ridges which connect neighbouring tubercles with one another are often slightly granulated with the same purple pigment.

In specimens in which the serial arrangement of the tubercles is not well defined, the general appearance is that of a central network of ridges, radiating out into irregular lines at the sides. The tubercles arise from the nodes of the network.

Since the general colour of the body is bright yellow, the contrast effected by the purple tubercles and ridges renders this little creature a very striking object in a mass of dredged material; it is, moreover, easily recognised as distinct from any British *Doris* hitherto described.

Doris maculata was first found by me at Plymouth on December 18th, 1893, when two specimens were dredged. It has since been obtained on several occasions, but always from the same locality—the western part of Plymouth Sound, known as the New and Queen's Grounds. The bottom here is clean, and consists largely of hard rock and stones, which graduate into beds of shells to the south. The flora and fauna are characterized by the occurrence of *Delesseria, Antennularia,* numerous *Polyzoa,* and *Morchellium argus.*

W. GARSTANG.

On the changes in the Pelagic Fauna of Plymouth during September, 1893 and 1895.—During a visit to the Plymouth Laboratory, in September, 1893, and in September, 1895, for systematic work on medusæ, it was almost a daily occupation to examine with a microscope the contents of the tow-net, for the purpose of obtaining the earliest stages of medusæ. Whilst thus occupied, I noted down not only the medusæ seen, but also other pelagic animals. I propose to give here a few notes to show the change in the pelagic fauna for the same month in different years. This is not intended for a complete list of all the animals seen, but only a few of the more interesting ones are given, and those which show the changes in quantity.

Noctiluca miliaris.—Bles (1892) states: "The absence of *Noctiluca* is a very extraordinary feature of the year, for 1891 was remarkable for the immense profusion of this infusorian, which in the months of June and July was present in such numbers that it discoloured large stretches of sea. This year it has been almost entirely absent, and a few individuals, which I found at the end of September, were the only signs of its existence." In 1893, I found *Noctiluca* almost daily in the tow-net, the quantity varying day by day. On some days the top of the tow-net jar was covered with a thick layer. In 1895 not a single specimen was seen during September.*

Liriantha appendiculata was exceedingly abundant in 1893, during September and the early part of October. Mr. Garstang sent me an adult male on October 23rd. I never saw a single specimen in 1895.

Amphinema dinema was fairly common during the whole of September, 1893; only a few small specimens seen in 1895, the last on September 20th.

Lar Sabellarum (= *Willia stellata*) was fairly abundant during the whole of September, 1893, especially the early stages; but scarce in 1895, and only medusæ belonging to the first and second stages were seen.

Dipurena halterata, a single specimen taken on 25th September, 1893. None seen in 1895.

Lizzia blondina was not taken during September, 1893; but Garstang obtained specimens during the summer months. During the early part of September, 1895, this medusa was fairly abundant, and disappeared about the middle of the month.

Solmaris and *Octorchis.*—Two early stages of a *Solmaris,* and a specimen of *Octorchis* were taken on 7th September, 1895, about two miles south of the Breakwater. Both genera are new to Plymouth. The *Solmaridae* (Narcomedusæ) inhabit the Mediterranean and the Tropical Seas. *Octorchis* is also a Mediterranean medusa. On 10th September, 1895, a new species of *Dipurena* was taken, and on the 17th September several specimens of *Euchilota,* also new to British seas.

The medusæ were certainly not so abundant in September, 1895, as in September, 1893. This may have been due to the enormous number of *Doliolum* and *Muggiæa* which daily entered the tow-net. In 1893, *Doliolum* was scarce during September, and *Liriantha* exceedingly abundant. *Obelia lucifera* was exceedingly plentiful during the whole of September, 1893, but in 1895, though a few specimens were taken daily at the beginning of the month, the great crowd did not appear until September 14th, then in the shallow water of Whitsand Bay, but soon swarmed everywhere, along with *Muggiæa and Doliolum.*

---

* *Noctiluca* did not appear until December, *vide* HODGSON, *infra,* p. 174.—ED.

Muggiæa atlantica, Cunningham.—Cunningham (1892) has given a description of this species. He first obtained specimens near the Eddystone on September 12th, 1891, "and afterwards it was obtained in great abundance close to the Plymouth Breakwater, and even inside the Sound. It was brought in numbers to the Laboratory almost every day up to about the middle of October, but after the end of that month it was not seen again."

Cunningham (1892), p. 398, gives an earlier history of this siphonophore, and also states that in 1892 it was very abundant at Plymouth, about the middle of September, but decreased considerably towards the end of the month.

In 1893, *Muggiæa* was present during the whole of September, and during the early part of the month fairly abundant. In 1895 it was exceedingly abundant.*

Beroe.—A single specimen taken on 19th September, 1895, about 3 mm. in length.

Echinoderm larvæ.—In 1893, Plutei were abundant during the early part of September, but very scarce towards the end. In 1895 several kinds were seen, some very abundant at the end of the month. The Bipinnariæ, described by Garstang (1894), were first taken at Plymouth in 1893, during August, and apparently disappeared before my arrival, as I saw none during September. But, in 1895, a few specimens were occasionally taken.

Pilidium.—I did not see any larvæ during September, 1893, but frequently saw them in 1895. Fairly abundant on September 7th and 19th.

Terebella.—The larval form in its tube was always present in the tow-net during September, 1893; a sudden increase occurred on September 23rd. In 1895, none seen until September 13th; after this date a few were generally present in the tow-net, but they were never abundant.

Chætopterus.—In 1893, one or two larvæ were usually taken every day. In 1895, a few were seen at the end of August, but none during September.

Polynoe.—In 1893 a few of the early larval stages were taken about the middle of September. In 1895 a few were occasionally seen, but scarce.

---

* Cf. HODGSON, *infra*, p. 174. It remained this year (1895) until the middle of December.—ED.

Magelona.—Abundant throughout the whole of September, 1893. On some days I counted the specimens seen—September 21st, 30; 22nd, 20; 23rd, 5; 25th, 50; 26th, 35; 27th, 38. On September 23rd all the Polychaete larvæ were scarce, but medusæ and other animals did not show any visible decrease. In 1895, Magelona was not nearly so abundant; often only a few present, occasionally none seen. On September 13th it was fairly abundant.

Mitraria.—This appears to be a rare animal on the southern coast of England. I only obtained three specimens on 31st August, 1895. Dr. Fowler informs me that some were taken a few years ago at Plymouth, but were not recorded in the journal. Vallentin (1891) records Mitraria for Falmouth in July, 1890.

Actinotrocha.—None seen during September, 1893. Very scarce in 1895; only a few specimens seen; the last taken on September 19th.

Rotifera.—Garstang (1894), p. 235, writes—"Apparently characteristic of this period (September) are the clouds of pelagic Rotifers, which may be occasionally taken." I cannot find any references to Rotifers in my notes for 1893. Certainly none appeared during Sept., 1895, as I kept a special look out for the benefit of a friend.*

Thalia democratica-mucronata.—Garstang (1894) states the nets were crowded with Salps in June, 1893. I saw none during September. In 1895 a few specimens were taken on September 9th only.

Doliolum tritonis.—In 1893 a few specimens were taken at the beginning of September, but soon became scarce. One or two occasionally taken at the end of the month. In 1895, Doliolum was exceedingly abundant at the beginning of September. Often the tow-nets were crowded with specimens. There was a gradual decrease towards the end of the month.

Tornaria.—None seen during September, 1893, but often taken in 1895. Fairly abundant at the beginning of September, and a few were occasionally taken at the end of the month. This is the same species, *Tornaria Kröhnii*, which Bourne (1889) found at Plymouth in 1888, during August and September.*

Amphioxus.—A specimen taken in the tow-net on September 3rd, 1895, about 2 mm. in length, and another on September 7th, about 3 mm. in length. None seen during September, 1893.

In some of the species the variation is great, as they are absent in one year and abundant in the other. Little value, however, can be attached to the slight differences in numbers, as a species may be present every year, but owing to its scarcity escape the tow-net, which after all only traverses through a very small portion of the sea, even in the course of a month. I have given these rarer forms to show that they do occur in September, and they may be of use to other naturalists on faunistic work.

---

* Cf. HODGSON, *infra*, p. 176-7.—ED.

The following list is drawn up to show more clearly the variation in the fauna for the two years:

	1893.	1895.
Noctiluca	abundant	absent.
Liriantha	„	„
Chætopterus	few daily	„
Dipurena	one	„
Amphinema	fairly abundant	all show a great decrease.
Lar (*Willia*)	abundant	
Magelona	„	
Doliolum	few	very abundant.
Pilidium	absent.	fairly abundant.
Tornaria	„	„ „
Lizzia	„	„ „
Actinotrocha	„	few.
Thalia	„	„
Bipinnaria	„	„
Mitraria	„	three.
Amphioxus	„	two.
Beroe	„	one.
Solmaris	——	all new to Plymouth.
Octorchis	——	
Dipurena (*sp.?*)	——	
Euchilota	——	

From this list it is easily seen that more interesting animals were taken during September, 1895, than in 1893. The cause is difficult to account for; it may, perhaps, be due to the weather, which was exceptionally fine during September, 1895. There was scarcely any rain, but plenty of sea mists and fogs; the last week of the month was exceptionally hot. The sea was usually calm; in fact, September was an ideal month for marine work.

The weather during the summer months was very changeable. Mr. Allen informs me that May and June were fine, July was stormy and wet. There was a spell of fine weather at the end of July, and during the first few days of August, then unsettled weather until middle of the month, when the fine weather commenced, which lasted till the end of September.

Garstang (1894) gives a general account of the weather for 1893, which may be of interest to quote for comparison :—

"The year 1893 was one of exceptional interest to the marine zoologist. During the first two months Plymouth experienced a continuous succession of heavy gales, but towards the middle of March the winds became lighter, and the sea, which had been running remarkably high outside the breakwater, subsided. From that time onwards till the middle of September we enjoyed six months of the most delightful weather—a period, with scarcely a break, of calm seas and almost cloudless skies. Under the influence of the great heat the temperature of the Channel waters rose continuously, until, in August, it had attained a point unprecedented for a quarter of a century; and it was of the highest interest to observe the effect of this high temperature, and of the prolonged calmness of the sea, upon the floating population of the neighbouring portion of the Channel. Numbers of semi-oceanic forms which rarely reach our shores arrived in remarkable profusion. In June the tow-nets were crowded with salps, while towards the latter end of August they were almost choked by masses of living Radiolaria." (p. 210.)

On looking up my notes for 1893, I find that the fine weather first broke up on September 6th, with a south-westerly wind with squalls of rain. The sea remained rough until the 11th, then followed a period of fairly calm seas until September 28th, when bad weather again set in till the end of the month. During the latter half of September westerly winds usually prevailed; rain fell nearly every day, and on two occasions showers of hail.

REFERENCES.

Bles, E. J. (1892).—"Notes on the Plankton observed at Plymouth during June, July, August, and September, 1892." *Jour. Mar. Biol. Assoc.* New Series, vol. ii. pp. 340-343.

Bourne, G. C. (1889).—"On a Tornaria found in British Seas." *Jour. Mar. Biol. Assoc.* vol. i. pp. 63-68. Pl. vii. viii.

Cunningham, J. T. (1892).—"On a species of a Siphonophore observed at Plymouth." *Jour. Mar. Biol. Assoc.* vol. ii. pp. 212-215, and p. 398.

Garstang, W. (1894).—"Faunistic Notes at Plymouth during 1893-4." *Jour. Mar. Biol. Assoc.* vol. iii. pp. 210-235.

Garstang, W. (1894).—"On some Bipinnariæ from the English Channel." *Quart. Jour. Micro. Sc.* vol. xxxv. pp. 451-459. *Pl.* 28.

Vallentin, R. (1891).—"Additions to the Fauna of Falmouth." *Rep. Roy. Cornwall Polytech. Soc.*

EDWARD T. BROWNE.

Notes on the Pelagic Fauna at Plymouth. August–December, 1895.—The following notes are by no means exhaustive, or even complete, and merely indicate the more important features of the varied characters of marine life during the period covered by them. In their compilation I have followed the system of a monthly calendar adopted by Garstang (8). If these notes are compared with those of other observers, certain differences present themselves, some striking, others trivial. That considerable and varied changes in the Floating Fauna do take place is sufficiently obvious, and they are doubtless strongly influenced by conditions of climate and currents. Garstang (**9**) briefly deals with the inter-relations of the Plankton; but very little accurate information on this point is available, and no explanation has yet been given of the periodic appearance and disappearance of certain forms. Thus, *Noctiluca* is recorded by Bles (**1**) as superabundant in 1891, scarce in 1892. Browne (**7**) comments on its abundance in 1893; Garstang (**9**) does not mention it for 1893 or 1894. I have only found a few individuals in December, 1895, a season quite at variance with the notes of other observers. *Muggiæa*, in 1895, appeared about the middle of August, as expected from previous notes; but it remained constantly present, or nearly so, up to the middle of December, two months later than in other years.

As regards Copepods, I have found *Oithona spinirostris* and *Corycæus anglicus* continuously from August to December, both inclusive, the former in diminishing numbers as the winter approached. Bourne (**3**) records both these species as occurring in the spring only; but, in another paper (**4**), refers to them both as being extremely abundant in the open sea in July. The non-appearance of *Paracalanus parvus* (Claus) is noteworthy.

With regard to other forms, Browne (**7**) has dealt in some detail with the more important features of the Plankton for September, and in comparison with a former period, so that there is but little for me to add, nor have I any other definite information of a similar season with which to make comparison.

Some reference is, perhaps, necessary to the observations of Prof. McIntosh, at St. Andrews (**10**). My own scanty notes accord, as far as they go, with his exhaustive record; but certain differences, probably due to locality, are conspicuous. In winter Ctenophores appear to be abundant, and of maximum size, at St. Andrews, but no trace of them exists at Plymouth. This is only one case in point.

The Tow-nettings were taken outside, and usually within a few miles of the Breakwater, at various depths from the surface, to about fifteen fathoms, but without any definite system. In this connection it is interesting to note that certain organisms usually rare, and first found in the open waters of the Channel, in the neighbourhood of the Eddystone, were this year abundant, and found comparatively close in shore. *Tornaria* (Bourne, 2) was fairly evenly distributed in the inshore and open-sea areas; *Doliolum* penetrated as far as the Sound; while *Muggiæa* was abundant within it.

AUGUST.—This month is perhaps the best in the year, or, maybe, it divides honours with September. This year, however (1895), the weather was distinctly prejudicial to good work outside the Breakwater, during the earlier part of the month.

Of the Crustacea, *Podon intermedius* (Lillj), and *Evadne Nordmanni* (Lowen), were constantly present, and a large proportion of the females carried ova. The Copepods *Cetochilus septentrionalis* (Goodsir), *Clausia elongata* (Boeck), *Dias longiremis* (Lillj), *Temora longicornis* (Müller), *Centropages typicus* (Kroyer), were invariably taken, the first-named in somewhat limited numbers, the remainder in more or less profusion. *Anomalocera Patersoni* (Templeton) only occurred once, on the 24th, when two individuals were taken. This conspicuous species is stated by Bourne (**3**) to be abundant in the late summer and autumn, though Bles (**1**) and Garstang (**9**) do not mention it.

Oithona spinirostris (Claus), recorded by Bourne (**3**) as an early spring species, was abundant all through the month, and, on the 23rd, females bearing ovisacs were taken. *Coryceus anglicus* (Lubbock), was also taken, though not previously recorded before September (Bles, **1**). Bourne (**3**) describes it as occurring from February to May. Nauplii were extremely abundant, more especially those of Cirripedes. The Zoœa of *Carcinus* appeared about the middle of the month, and soon became abundant, with the larvæ of various other Decapods.

Of Ascidians, *Oikopleura dioica* (Fol), was frequently present, though by no means abundantly. On the 26th, *Doliolum tritonis* (Herdman), appeared for the first time. The Ctenophore *Hormiphora plumosa*, (Agassiz), almost invariably occurred in small numbers. *Muggiæa atlantica* (Cunningham), appeared on the 13th, and from that time forward was constantly present.

From the middle to the end of the month the tow-nettings were taken well within two miles of the Breakwater, and from the 20th onwards the medusoid forms of *Obelia* appeared numerously, but in somewhat fluctuating quantities; and together with them a few other medusæ. Larval forms in abundance made their appearance towards the end of the month. Echinoderms were among the first, with several species of Plutei, and a few Bipinnaria. An occasional Tornaria, *T. Kröhnii*, followed by a variable number of *Trochospheres*, *Pilidia*, &c., and post-larval stages of numerous Polychætes. *Cyphonautes* also appeared in fair numbers. *Spadella bipunctata* occurred somewhat sparingly near the end of the month, and the individuals were of moderate size only. *Ceratium* was taken very sparingly on three occasions, and Diatoms of the genus *Rhizosolenia* were not uncommon.

September.—The calm and hot weather prevailing almost entirely through this month, if it did not directly increase pelagic life, was decidedly more favourable for its capture. All the Entomostraca mentioned last month were found, and from the 7th to the 14th were particularly abundant. More especially was this the case with *Cetochilus septentrionalis.* Ova-bearing females of *Clausia elongata* were taken on the 23rd, and females of *Corycæus anglicus* in a similar condition at short intervals throughout the month. *Podon intermedius* diminished considerably in numbers.

On the 13th, Mr. E. T. Browne brought me a fine specimen of the rare *Monstrilla Danæ* (Claus), and I obtained another on the 18th. This species does not appear to have been recorded in this neighbourhood since 1889, when Messrs. Bourne and Norman obtained no less than eight specimens, then its first appearance (**5**). *Nauplii*, of various species and stages, became very abundant, and among the equally numerous Decapod larvæ, the Zoœa of *Porcellana* were conspicuous. *Spadella bipunctata,* of small to moderate size, were fairly abundant, and larval forms of all kinds were more numerous than before. *Tornaria,* fairly numerous at first, was not taken by me later than the 24th. *Plutei,* invariably present, were particularly numerous 7th, 9th, 18th, and 30th. *Trochospheres* and *Pilidia* were plentiful, and the larvæ of Terebella appeared in small numbers, but on the 18th were fairly abundant. *Doliolum tritonis* was more or less abundant throughout the month, and on the 9th a few specimens of *Thalia democratica-mucronata* (Lusk) were taken. *Oikopleura* maintained its numbers as in August. *Muggiœa* was abundant throughout the month, sometimes exceedingly so. *Ceratium* occurred occasionally in small numbers, and Diatoms were fairly plentiful, more particularly so on the last day of the month, when the tow-net was quite choked with them.

OCTOBER.—The diminution of numerous forms of life, indicated towards the end of September, became very conspicuous during October. *Podon* and *Evadne* disappeared early, and were soon followed by *Centropages typicus. Clausia elongata, Oithona spinirostris,* and *Corycæus anglicus* alone maintained their numbers, and of the two latter ova-bearing females were frequently found. *Nauplii* and *Decapod* larvæ became scarce. *Doliolum* disappeared on the 13th, but *Oikopleura* appeared more frequently, seldom a tow-netting without it. A fine specimen of *Tomopteris onisciformis* (Eschsch), was taken on the 22nd. *Spadella* increased in numbers and in size. Post-larval stages of many *Polychœtes* were still abundant, and with them *Cyphonautes* maintained itself without perceptible variation. *Muggiœa* was still abundant, and accompanied by its larval form. *Obelia,* with one sudden and conspicuous accession to its numbers, died out, and with it the few Medusæ associated with it. This increased number of Obelia was taken about a mile from the Breakwater. Diatoms, which were inconveniently conspicuous for the first day or two, resumed normal proportions.

NOVEMBER.—*Clausia elongata* became the most conspicuous Copepod. *Coryecus anglicus* also maintained its numbers, but the remainder diminished considerably. The not uncommon *Longipedia coronata* was taken twice, previously only recorded by Bourne (3) in March and April, 1889. *Harpacticus chelifer* was also taken once. This species does not appear to have been recorded at all, though it is fairly common in the littoral and laminarian zones. The Copepods frequenting these regions have been quite neglected.

Two specimens of *Caligus rapax* were taken free swimming. *Nauplii* and *Decapod* larvæ were reduced to a minimum. *Spadella*, at times numerous, was rather small. A single specimen of *Tomopteris* was taken on the 23rd. The post-larval stages of various *Polychætes* were fairly numerous, and, for a time, the larvæ of *Terebella* also. Echinoderm larvæ were rare, one or two *Plutei* being occasionally found. *Cyphonautes* were fairly numerous, and *Muggiæa*, with its larva, was generally present in small numbers. *Obelia* was occasionally represented by a few stragglers.

Diatoms were plentiful, and *Ceratium* was only found occasionally, and in very limited numbers.

DECEMBER.—This month was very similar to the last. *Oithona spinirostris* was only occasionally found. On the 18th, a fine specimen of *Candace pectinata*, Brady, was taken. This species has not hitherto been recorded in this neighbourhood, and, as far as I know, only once for the British Seas, when it was taken by Professor G. S. Brady (6), off the Scilly Isles. *Spadella* still increased both in numbers and in size.

Muggiæa disappeared altogether about the middle of the month. On the 20th, *Ceratium* was taken more numerously than before, and with it was a fair sprinkling of *Radiolaria*. These occurred for the first and only time, but are mentioned by Garstang (9) as frequently abundant in the summer. At the same time a single Rotifer was seen, again the only occasion, and rather a contrast to the frequent clouds of these organisms that Garstang (9) reports as generally occurring in August and September.*

Noctiluca was frequently present, but in extremely limited numbers.

REFERENCES.

1. Bles, E. J.—"Notes on the Plankton, observed at Plymouth during June, July, Aug., and Sept., 1892." *Jour. Mar. Biol. Assoc.* New Series, vol. ii. pp. 340-3.

2. Bourne, G. C.—"On a Tornaria found in British Seas." *Jour. Mar. Biol. Assoc.* New Series, vol. i. pp. 63-68.

3. Bourne, G. C.—"Report on the Pelagic Copepoda collected at Plymouth in 1888-89." *Jour. Mar. Biol. Assoc.* New Series, vol. i. pp. 144-152.

4. Bourne, G. C.—"Report of a Cruise of *H.M.S. Research* off the south-west coast of Ireland." *Jour. Mar. Biol. Assoc.* New Series, vol. i. pp. 306-321.

5. Bourne, G. C.—"Notes on the Genus Monstrilla, *Dana*." *Quart. Journ. Micr. Sci.* vol. xxx. 1890, pp. 565-578.

---

* *Cf.* BROWNE (7), p. 171.

6. Brady, G. S.—"Monograph of the British Copepoda." *Ray Society*, vol. i. 1878, pp. 49, 50.

7. Browne, E. T.—"On the changes in the Pelagic Fauna of Plymouth during September 1893 and 1895." *Jour. Mar. Biol. Assoc.* vol. iv. pp. 168-173.

8. Cunningham, J. T.—"On a species of Siphonophore observed at Plymouth." *Jour. Mar. Biol. Assoc.* New Series, vol. ii. pp. 212-215.

9. Garstang, W.—"Faunistic Notes at Plymouth during 1893-4." *Jour. Mar. Biol. Assoc.* vol. iii. pp. 212-235.

10. McIntosh, W. C.—"On the Pelagic Fauna of the Bay of St. Andrews during the months of 1888." *Seventh Ann. Rep. Fish. Bd. Scot.* part iii. 1889, pp. 259-301.

T. V. Hodgson.

Nautilograpsus minutus, Milne Edwards.—On September 26th a large three-masted sailing-ship, the *Ballachulish*, of Ardrossan, entered the Sound from a distant port, and enquiry from the Agents showed that she had come direct from Iquique, in Peru, and that for nearly two years previously she had been trading in the Central Pacific.

As the Laboratory boat was passing on the 28th, it was stopped to make a rough examination of the ship's bottom for specimens, and a fine male specimen of *Nautilograpsus minutus*, M. Edw., was taken. This species is a native of the Sargasso Sea, and only a very rare straggler to the British coasts. It is described by Bell * under the name of *Planes linnæana* (Leach), and he states that there are several species of this genus. Stebbing, however, in his *Crustacea*,† reduces the reputed species to one, and substitutes Milne-Edwards' name for that of Bell. The bottom of the ship was covered, in patches, with a number of fine specimens of *Lepas anatifera*, and a single specimen of *Conchoderma aurita* (Spengel) was taken. With these and some green algæ was an enormous quantity of *Tubularia sp.* The latter was in fine condition, and both male and female reproductive organs were well developed. Specimens were taken by Mr. E. T. Browne for identification, and will be described by him. Overrunning both alga and *Tubularia* was a crowd of large *Podocerus falcatus*.

On October 21st a fisherman brought to the Laboratory an enormous bunch of *Lepas anatifera*, fixed to a fragment of some cork structure—thick sheets of cork secured together by wooden pins—found floating in the Channel some two or three miles out. Concealed in this mass was another specimen of *Nautilograpsus minutus*. (M. Edw.) Both specimens were about half an inch across the carapace, and of a reddish colour, but the second specimen had a broad band of white across the anterior portion.

T. V. Hodgson.

---

* Bell, T.—*History of the British Stalk-eyed Crustacea*, London, 1853.

† Stebbing, T. R. R.—*Crustacea.* Int. Sc. Ser. 1893.

Algological Notes.

By

George Brebner.

The following list shows the additions made to the marine flora of Plymouth and district, as a result of the dredging, &c., carried on from the 6th September to the 10th December, 1895.

MYXOPHYCEÆ, *Stizenb.* (= Cyanophyceæ, *Sachs*).

Lyngbya Meneghiniana, Gom. (West Hoe).
Phormidium persicinum, Gom. (Duke Rock).
Plectonema terebrans, Born. et Flah. (Cawsand Bay).
Mastigocoleus testarum, Lagerh. (Drake's Island).

CHLOROPHYCEÆ.

Gomontia polyrhiza, Born. et Flah.
Ostreobium Queketti, Born. et Flah.

PHÆOPHYCEÆ.

Desmarestia Dresnayi, Lamx. (Eddystone, &c.).
Ectocarpus velutinus, Kütz. (Rocks at Ladies' Bathing Place, &c.).
„ „ var. *laterifructus*, Batt. in lit. (Rocks at Ladies' Bathing Place, Rum Bay, Firestone Bay, &c.).
Ectocarpus terminalis, Kütz. (Firestone Bay).
Leptonema fasciculatum, Rke. var. *uncinatum*, Rke. (Cawsand Bay).
Ralfsia clavata, Crn. (Drake's Island).
„ *spongiocarpa*, Batt. (Wembury Bay).

FLORIDEÆ.

Those marked * are new to science, † new to Britain.

Conchocelis rosea, Batt. (Cawsand Bay, &c.).
**Colaconema Bonnemaisoniæ*, Batt. in lit. (Eddystone, Mewstone, &c.).
* „ *Chylocladiæ*, Batt. in lit. (Bovisand Bay, &c.).
* „ *reticulatum*, Batt. in lit. (Dredging 34).

Callocolax neglectus, Schmitz (Bovisand Bay, &c.).
Phyllophora Traillii, Batt. (Bovisand Bay, Duke Rock, &c.).
Trailliella intricata, Batt. in lit. (Cawsand Bay).
  (= *Spermothamnion Turneri*, var. *intricatum*, Holm. et Batt. Rev. List.)
Rhodochorton membranaceum, Mag.
  var. *macrocladum*, Rosenv. (Eddystone).
Rhodochortun minutum, Rke. (Cawsand Bay).
Cruoria adhaerens, Crn. (Queen's Ground).
† „ *rosea*, Crn. (Queen's Ground).
† *Rhododiscus pulcherrimus*, Crn. (Queen's Ground).
Cruoriella Dubyi, Schmitz (Queen's Ground).
Rhododermis parasitica, Batt. (Bovisand Bay).
Melobesia Lejolisii, Rosan. (Cawsand Bay).

Colaconema Bonnemaisoniæ, Batt. in lit., was first recognised in the "fruiting" condition (monospores) in a fragment of *Bonnemaisonia asparagoides*, dredged off the Eddystone Lighthouse on the 9th September. It was made the type of a new genus of endophytic algæ. On the same expedition the interesting *Desmarestia Dresnayi*, Lamx., was obtained, and in the perfect condition, *i.e.* with a main frond, having two smaller lateral fronds near the base, symmetrically placed one on each side. Subsequently, in adjacent waters, 26th September (haul 34), a very fine specimen of the same plant was secured.

Colaconema Chylocladiæ, Batt. in lit., was recognised in fruiting condition (monospores) in a tetrasporogenous specimen of *Chylocladia ovalis*, dredged in Bovisand Bay, 20th September. Well-"fruited" specimens of this species had previously been obtained by Mr. Batters at Torquay, although he had not named, or published, his find.

Colaconema reticulatum, Batt. in lit., was found on a very broad old frond of *Desmarestia Dresnayi*, Lamx.; but as its reproductive organs have not yet been recognised, it is only tentatively placed here in the classification. It had previously been found elsewhere by Mr. Edward Batters.

Trailliella intricata, Batt. in lit., has been made the type of a new genus, on account of the discovery of the tetraspores of the plant. This alga had already found a place in the classification as indicated in the above list. As it was placed from barren specimens, the discovery of the tetraspores, which are unique in position and mode of development for the *Calithamnions*, rendered re-classification necessary. It was named in honour of Mr. G. W. Traill, the well-known Scottish algologist.

Cruoria rosea, Crn., and *Rhododiscus pulcherrimus*, Crn., new to Britain, are interesting members of the Squamariaceæ, and were found by Mr. Batters on shells forwarded to him from the Laboratory.

All the above finds were authenticated by Mr. Batters, to whom the writer's heartiest thanks are due for his invaluable advice and assistance. The writer likewise wishes here to express his great indebtedness to the Director and staff of the Laboratory for the aid rendered in the carrying out of these investigations.

NOTE.—The diagnoses of the new genera, and further information about the more important of the above finds, written by Mr. Edward Batters, will be found in the *Journal of Botany* for January, 1896.

The Protection of Crabs and Lobsters.

By

E. J. Allen, B.Sc.
Director of the Plymouth Laboratory.

> "Every legislative restriction means the creation of a new offence. In the case of fishery it means that a simple man of the people, earning a scanty livelihood by hard toil, shall be liable to fine or imprisonment for doing that which he and his fathers before him have, up to that time, been free to do.
>
> "If the general interest clearly requires that this burden should be put upon the fisherman—well and good. But if it does not—if, indeed, there is any doubt about the matter—I think that the man who has made the unnecessary law deserves a heavier punishment than the man who breaks it."—HUXLEY, Inaugural Address, Fisheries Exhibition, 1883.

SEVERAL of the local Sea Fisheries Committees have recently been, or are still engaged in, considering the question of the advisability of adopting restrictive measures for the protection of crabs and lobsters within their respective districts. To Mr. Gregg Wilson, of the Natural History Department of Edinburgh University, I am indebted for copies of two reports on the subject prepared by him for the Northumberland Sea Fisheries' Committee; to Mr. W. H. St. Quintin, chairman of the North-Eastern Committee, for a copy of the evidence taken by their sub-committee from fishermen at various centres in the district; and to the clerk to the Cornwall Sea Fisheries' Committee for a copy of the report of their sub-committee, signed by Mr. E. W. Rashleigh, and a summary of the evidence taken prepared by Mr. Rupert Vallentin. The committee of the Eastern District have, I understand, also had the matter under consideration.

In all cases the suggested restrictions are of two kinds: (1) the establishment of a close-season; and (2), an increase of the present size limit.

With regard to the first of these proposed remedies, it is hardly necessary to point out, that from a scientific standpoint a close-season for any animal can, in the majority of cases, only be justified, when the breeding season of the animal extends over only a limited portion of the year, and when the close-season can be made to correspond with the breeding season. That any attention should be paid to such arguments as those brought forward by the Looe fishermen in favour of a close time, namely, that the "nets belonging to the drift fishermen become entangled with the floats, which mark the positions of the crab or lobster pots," appears to me to be quite unjustifiable.

The biological question is, in the case under consideration, considerably complicated by the fact that the breeding seasons of the crab and lobster are very different, as well as by the circumstance that both these crustaceans periodically cast their shell, and remain for some time in a soft state, when they are quite unfit for food. It is necessary for us therefore to consider, in the first place, each of the animals independently, and then, bearing in mind that both are caught at the same time and in the same traps, and that in most cases to try to establish a close-season for one and not for the other, would make the fishing during that time quite unprofitable, we must endeavour to ascertain whether, on the whole, one close-season could be justly enforced.

With regard to the reproductive habits of the lobster, we have considerable accurate information. In the last number of this Journal I endeavoured to give a summary of the present state of knowledge on the subject, from which it appeared that most lobsters laid their eggs in August, and that most of these eggs were hatched in the following June, being carried by the female for ten months. During July, the number of females bearing eggs was not large, and of these some carried eggs on the point of hatching, whilst others carried those which had just been laid, the two seasons to some extent overlapping. The evidence given by the fishermen at the different enquiries quite agreed with this statement, for they maintained that they took berried hen lobsters all the year round, and could point to no month in which they were undoubtedly specially numerous. For the lobster alone, therefore, it does not, under these circumstances, appear that any particular period of the year could be legitimately recommended as a close time. A more practical suggestion from the point of view of maintaining the species is that there should be a perpetual close time for berried hens, that is, that the taking of females carrying eggs should be entirely prohibited; and in one locality, at least, in the North Eastern District, a fisherman was found who appeared to be strongly in favour of this extreme step.*

On the other hand, in certain districts it is maintained that such a proceeding would practically close the fishery. Whether or not this would be the case depends on the proportion which the number of berried females bears to the whole catch. The data for determining this proportion are not numerous. From Ehrenbaum's table,† it appears that out of a total of 3,470 lobsters (unsorted catches) counted by him at Heligoland, between November, 1892, and July, 1893, 383 were females carrying eggs, that is, 11 per cent. of the total number taken. Of the lobsters taken by one boat at Plymouth* during May, June, and the first half of July, 1890, about 6½ per cent. were berried females. These numbers represent, therefore, the nearest approximation we can get at the present time as to the amount of loss which the men would immediately suffer, if they were compelled to return all berried females to the sea. In his report to the Northumberland Committee, Mr. Gregg Wilson recommends that there should be a close time for berried hen lobsters only, during the months of June and July, on the ground that more berried females are got during those two months than at other times of the year. I can only say that, according to my experience at Plymouth, it is more difficult to obtain berried lobsters in July than during any other month when the boats are fishing.

---

* *Report*, p. 100.

† Reprinted in this Journal, vol. iv. p. 64.

With respect to the crab, however, the facts are in many important respects different from what they are in the case of the lobster.

In the first place, the berried crabs are already protected under the Fisheries Act, 1877, it being illegal to buy, sell, or have in one's possession such crabs, and in the second place, these crabs never, or very rarely, enter the pots. When in spawn they migrate to the deeper water, and appear to bury themselves in the sand. At any rate, they are taken in this condition from smooth ground by the trawlers.

As to the spawning time of the crab, Mr. Gregg Wilson gives some interesting information derived from his own observations on the coast of Northumberland, and comes to the conclusion that the spawning period includes November, December, and January. A large proportion of the take of crabs during these months consists of females which are just about to spawn, and Mr. Wilson suggests that these might be protected, and proposes a close time from the 1st of September to the end of January. As an additional argument in favour of this close time he adduces the fact that many crabs during these months are soft, that is, have cast their shell and are quite unfit for food. In November, two out of every three crabs were found to be "casters," and although the men profess to throw these soft crabs back, many of them are so much injured by the rough treatment they receive that there is little chance of their surviving.

"I know of one village," says Mr. Wilson, "where the sorting of the crabs is done, not at the fishing grounds, but on dry land, and where, too, it is done so badly, that as little as a shilling a barrel was got for crabs sent to market in November; and I know another village where the men confess that if the law against the sale of caster-crabs could be strictly enforced, they would have to give up fishing in the late months of the year."

---

* This Journal. Vol. ii. N.S. p. 15.

Such, then, are the facts upon which the desirability or otherwise of establishing a close time for crabs and lobsters has to be decided. And it appears to me that, taking these facts as a whole, the Sub-Committee of the Cornwall Sea Fisheries' District adopted the only reasonable course in deciding that no close time could be recommended. For not only do the lobsters carry their spawn equally during at least eleven months of the year, whilst the berried crabs never enter the pots at all, but during the winter months, when it is proposed that the close time should be established, very little fishing takes place, owing to the stormy weather which then prevails. There is, in fact, a natural close time imposed by this cause, which, under any circumstance, would render legislative interference unnecessary.

Passing to the second of the proposed restrictions, viz., an increase of the present size limit, we have first to consider the basis upon which legislation of this kind rests. I cannot do better, in order to make this clear, and to give both sides of the argument, than quote the following from the report of the enquiry held by the Sub-Committee in the North-Eastern Sea Fisheries' District—

"By Mr. Pannett—*

"*Q.* Before asking the next question, I would explain that in considering what should be the size—the smallest size—at which crabs and lobsters should be allowed to be taken, there are two classes of men who each hold different opinions. There are those who are of opinion that crabs and lobsters might fairly be taken as soon as they can be sold, as soon as they are marketable; that is, not to take them wastefully, not to take them for children to play with, not to take them wantonly, not unless they can be sold in the market. These people think the fish should not be allowed to remain in the sea until they get their growth, but that they should be allowed to be taken as soon as they can be sold in the market. Now there is another class of men who say that that is a very improper rule; they say that crabs and lobsters which are not able to reproduce their species, are not able to breed till they reach, on an average, a certain size, although they may be marketable below that size, although they might be sold for money below that size, should not be allowed to be taken till they reach the size at which they have had the chance of breeding once. If so, every she-crab and hen-lobster would, before being killed, have a chance of reproducing one brood to take its place. . . . Would you object to a crab being allowed to grow to the size at which it should breed once before it should be taken, or would you claim that it might be taken as soon as it was saleable?

"*A.* (Fisherman.) As soon as it was saleable."

---

* *Report*, p. 58.

Again, to another witness.*

"By Mr. Pannett—

"*Q.* If they do not breed till they are much larger than four-and-a-quarter inches, do you not, by killing all the crabs that are under the breeding size, stop the supply of crabs from these fish?

"*A.* (Fisherman.) I don't think so.

"*Q.* How is the supply to be kept up if you kill the crab before sufficient time is allowed for it to spawn once?

"*A.* (Fisherman.) We don't kill them all.

"By Mr. Mally—

"*Q.* With reference to what Mr. Pannett was asking you. Suppose all girls are killed when they are twelve years of age, there would be no young women or young children; that is what we wanted to know. I think you understand that, and if young crabs under the age at which they can spawn be killed, it follows that there can be no crabs from them?

"*A.* (Fisherman.) But crabs breed a deal different to what girls do. Crabs, when they spawn, spawn many a thousand at a time."

There is, of course, also another point of view from which the protection of undersized animals may be advantageous to the fishery, in addition to this matter of allowing each animal to breed once, viz., that if the small crabs or lobsters, which are of little value, be returned immediately to the water, they themselves will grow, and become much more valuable.

Under the Fisheries Act (1877) a limit has already been fixed, below which it is illegal to take either crabs or lobsters. For crabs, the minimum size is 4¼ inches, measured across the broadest part of the back, and for lobsters 8 inches, measured from the tip of the beak to the end of the tail. Now both these sizes are considerably below the sizes at which the greater number of the animals begin to breed, so that at the present time large numbers of both crabs and lobsters are sold at very low prices indeed, which have never had an opportunity of breeding, and so helping to maintain the future supply. It appears to be in the direction of raising the limit that legislative interference can with advantage take place. According to Mr. Gregg Wilson's observations, which are, however, not very definite on this head, the majority of female crabs do not spawn until they reach a size of from six to seven inches, whilst the males may be ripe at five inches. In the case of lobsters, although a few females may spawn at eight inches, it does not appear that many do this under ten inches. Hence the limits which would be recommended from purely biological considerations would be, for female crabs at least six inches, for male crabs five inches, for female lobsters ten inches, with possibly a lower limit for the males.

---

* *Report*, p. 76.

It must not, however, be forgotten that according to the evidence given in the North-Eastern District, the immediate effect of such limits would be, in certain places, at any rate, to entirely stop the fishing, and it would be several years before any very great benefit could follow from the fact that more of the crabs had been allowed to breed. On the other hand, if the limit could be raised gradually, the beneficial effect might be slowly brought about without entailing any sudden hardship upon individuals. This might be done by adopting the recommendation of Mr. Wilson, viz., a limit of five inches for crabs, and by raising the limit for lobsters to, say, nine inches. It is more than probable that if these limits were maintained for a few years, sufficient improvement in size would have taken place to allow of their being raised to the more reasonable standard without serious injury to any individuals.

Report on the Sponge Fishery of Florida and the Artificial culture of Sponges.

(Prepared at the request of the Colonial Office, with a view to the introduction of Sponge Culture in the Bahamas.)

By

E. J. Allen, B.Sc.,

Hon. Secretary of the Marine Biological Association, and Director of the Plymouth Laboratory.

SUMMARY.

I. The Florida Sponge Fishery.—History of the Fishery. Kinds of sponges taken. Relative value of sponges. Methods of procuring sponges. Curing the sponges. Sponge grounds reduced in value through over-fishing.

Sponge Culture Experiments.—Historical.

Experiments of Buccich.—Description of apparatus used, and manner in which the experiments were conducted. Buccich concluded that sponge cuttings would grow to marketable size in seven years.

Experiments in Florida.—Sponge cuttings said to grow more rapidly, increasing to from four to six times their original size in six months, when placed under favourable conditions.

Memorandum by Mr. Benedict, of U.S. National Museum.—Sponge culture experiments do not appear to have been tried to any great extent. Fishermen opposed to anything of the kind as likely to lead to monopoly, and the cutting off their means of subsistence.

Would Sponge-culture by Cuttings be Profitable ?—Marenzeller points out that this would depend on whether pieces of a sponge would in a given time together attain a greater weight than the original sponge would have reached if left undisturbed.

Suggested Experiments.—Suggestions by Mr. Bidder (*see below*). Fishing by means of divers, or dredging, should be tried in deeper water.

II. Note on Projects for the Improvement of Sponge-Fisheries. By Mr. George Bidder.

A. There appears no reason yet to suppose that the yield of a sponge-fishery will be increased by planting cuttings, unless these are placed in more advantageous positions than the original sponges. Such advantage may probably be obtained by attaching either cuttings or small sponges to canes or tiles, disposed on iron hurdles standing some feet from the sea-bottom. No certain statement, however, can be made with regard to any project, until there has been effected a series of accurate observations on the natural growth of the sponge of commerce.

B. Sponges could probably be transported alive from the Mediterranean to the Bahamas, but it is not certain that even if they bred freely, their progeny would maintain the superior character of the parents.

C. There is no special breeding season for sponges.

APPENDIX.—Rate of Growth of Sponges.

THE FLORIDA SPONGE FISHERY.*—It was not until the year 1850 that the attention of American sponge merchants was directed to the fact that the reefs of South Florida possessed an abundant growth of sponges. Previous to that time, all sponges sold in America had been obtained from the Mediterranean or the Bahamas. When, however, the true value of the Florida sponges was once realised, an important industry grew rapidly, the island of West Key and the town of Apalachicola being at the present time chiefly interested in the promotion of the fishery.

In Florida, as in the Bahamas, five principal grades of sponges are recognised. The most valuable of these is the *sheepswool* sponge, which is regarded by naturalists as a variety of *Hippospongia equina*, the horse-sponge and Venetian bath sponge of the Mediterranean. The representative in America waters of *Euspongia officinalis*, the Levant toilet sponge and the Turkey cup sponge, the most valuable kinds found in the East, is the *glove* sponge, which is, however, the least valuable of the American grades. The grades intermediate in value between the *sheepswool* and the *glove* sponges are the *velvet*, another variety of *Hippospongia equina*, the *yellow*, and *hard-head sponges*, which may belong to the same species as the Mediterranean Zimocca sponge (*Euspongia zimocca*), and the grass sponge (*Spongia graminea*, possibly a variety of *Euspongia officinalis*), a grade of little value.

By far the most costly sponges in the market are those from the Mediterranean, the sheepswool sponges of the Bahamas and Florida being regarded as the next in quality. Of the latter, the Florida sponges are said to be superior to those sent from the Bahamas, being supposed to possess a somewhat finer texture, and a more regular and compact mode of growth. The irregularity of shape of the Bahama sponges is stated to be due to the irregular nature of the bottom on which they grow.†

The method by which the sponges are procured in Florida is similar to that practised in the Bahamas, but differs essentially from the usual

---

* The following account has been compiled, for the most part, from an article by Rathbun in "The Fishery Industries of the United States" (Section V. vol. 2, p. 819), published by the U.S. Commission of Fish and Fisheries, Washington, 1887. The discussion of the question by Dr. Juan Vilaro [*Esponjicultura cubana*, Revista de Pesca Maritima VII. Madrid, 1891], was also consulted; it is compiled chiefly from the American Reports.

† The method of preparation of Bahama sponges is also stated to be inferior to that practised in Florida.

Mediterranean mode of fishing. In the latter case the sponges are generally obtained by divers from depths of from 15 to 20 fathoms, the men working without a diving dress, using large stones, which they hold at arm's length in front of them, to carry them to the bottom. They usually remain under water about two minutes. In America, on the other hand, sponges are taken in water of from 3 to 6 fathoms, or even shallower, by means of a three-pronged hook fixed at the end of a pole, men working the poles from small boats. The sponges are seen from the surface with the aid of a "sponge-glass," which is generally a wooden bucket painted a dark colour inside, and with the bottom replaced by a sheet of glass. When the glass is plunged below the surface of the water, the effect of the surface ripples is removed, and by looking through the bucket a clear view of the sea-bottom can be obtained even at considerable depths. As soon as a sponge is seen it is taken by means of the hooks. At the end of a day's fishing, the small boats, each of which is usually occupied by two men, return with their catches to the sponging vessel, which has been lying near all day, and the sponges are placed on board. Some of these vessels remain on the fishing grounds for from one to three months, whilst others return to port at the end of a week or fortnight only. It is generally usual, however, for the vessels to take their catch every week to the "crawls"—enclosures of stakes 8 or 10 feet square, situated in water 2 to 3 feet deep—in which the sponges are cured. The process of curing consists in allowing the animal portion of the sponge to rot, and then clearing it away by squeezing and beating. As much of the water as possible is pressed out, and the sponges then strung on rope yarns, and hung up to bleach and dry. The only other processes to which they are subjected before being placed upon the market are "liming" and trimming, but both of these are carried out after they have passed out of the hands of the fishermen into those of the dealers. The "liming" consists in dipping the sponges in a weak solution of lime in sea-water, and subsequently drying them, a treatment which adds to their value by giving them a bright yellow colour. This process requires to be very carefully performed, as too much lime is liable to injure the tissue of the sponge.

When sponge-fishing was first practised on a large scale in Florida, only the larger sponges were taken, but in consequence of the amount of fishing which was carried on, the number of large sponges became insufficient to supply the demand, and the smaller ones were gathered to make up the requisite quantity. It became evident, however, that the value of the grounds would soon become considerably reduced, and those interested in the matter began to consider the possibility of increasing the number of sponges by attempting their artificial cultivation. Unfortunately, however, up to the present time, the matter does not appear to have been carried beyond a very elementary experimental stage.

SPONGE CULTURE EXPERIMENTS.—The statement that detached sponges were capable of fixing themselves and continuing their growth, was first recorded in 1785 by Filippo Cavolini, his account being based upon experiments carried out in the Bay of Naples. It was not, however, until the year 1862 that attention was drawn by Professor Oscar Schmidt to the fact that portions of a sponge would also fix and grow, and the possibility of its application to the production of sponges on a commercial scale pointed out.

EXPERIMENTS OF BUCCICH.—In consequence of the opinion expressed by Professor Schmidt, "that if a perfectly fresh sponge is cut in suitable pieces, and if these pieces, properly protected, are again placed in the sea, they will grow and finally develop into complete sponges," a number of experiments were made during 1863-1872, at a station established on the bay of Socolizza, at the north-eastern point of the island of Lesina. This establishment was closed in 1872, on account of the hostility of the native fishermen, who continually interfered with the growing sponges. An account of these experiments has been given by Dr. Emil von Marenzeller,* from the original notes of Signor Gregor Buccich, who was in charge of the establishment. The experiments seem to show that for European sponges cuttings, if carefully treated, can be reared successfully until they become of marketable size. From the account given, it appears that for making sponge-cuttings the most favourable time is during the winter months, as in cool weather there is less tendency for the sponges to suffer from detachment and exposure to air. The best localities are sheltered bays, with pure sea-water as free as possible from mud. The sponges from which the cuttings are to be made require very careful treatment, and the method finally adopted by Buccich was as follows: The sponges having been obtained either with tongs or a drag-net, and the injured portions, as far as possible, removed, they are fixed by means of wooden pegs to the inner side of a sort of fish-box, which is towed behind the boat. It is better, especially in warm weather, to leave the sponges for a little time in this box, in order to see whether or not putrefaction is likely to take place. When it has been ascertained that all the sponges are healthy, the cutting and planting are proceeded with. The cutting is done upon a small board, moistened with sea-water, with a knife having a saw-edge, and the pieces are made so as to measure about an inch each way.

---

* Die Aufzucht des Badeschwammes aus Theilstücken. Verhandl. der k.k. Zoologisch-botanischen Gesellschaft in Wien. Vienna, 1878. Translated in U.S. Fish Commission Report, 1879; p. 771.

Each piece should have as large an area as possible of intact outer skin. Various methods of planting the cuttings were tried. The pieces, especially those with only one cut surface, very soon attach themselves to a suitable base either of stone or wood, if brought into close contact with it. They must, however, in general be fastened in some way to prevent them from being moved about by waves and currents. Amongst other methods tried by Buccich was that of fixing the pieces by means of wooden pegs upon flagstones, in which holes were bored. But in this case the mud and sand on the bottom, and possibly also the excess of light, proved injurious. The apparatus finally adopted consisted of two boards, about 25 inches long and 16 inches broad, kept in a parallel position one above the other by two props placed at a distance apart of about 4½ inches, and having their opposite ends fixed to the boards. Between the props stones could be put as ballast. Twenty-four holes, at distances of 4¾ inches from each other, were bored in each board, into which the two ends of as many bamboo rods could be fastened, thus forming a kind of vertical grating. Before, however, the bamboo rods were placed in position, the pieces of sponge were fixed to them in the following way: Three holes were made in each rod, at equal distances apart, and each piece of sponge was perforated with a hole sufficiently large for it to be able to slide on the rod. Three pieces of sponge were put on each rod, and supported on wooden pegs placed through the holes in the latter. In order to perforate the sponge-cuttings without injuring them, a trepan about a quarter of an inch wide, kept in rapid motion by a fly-wheel, was used. When the pieces of sponge had been fixed on the rods as described, and the rods placed in position in the frame, the whole was sunk to the bottom and allowed to remain. All wood used in the apparatus was well tarred, in order to prevent the destructive action of boring molluscs, and for this purpose it would be advisable, in any future experiments, to construct the apparatus of iron. It was found that if due care had been taken, 90 per cent. of the cuttings developed successfully, and Buccich states that they were found to grow two or three times their original size during the first year. He was of opinion that although some pieces will grow to a considerable size in five years, it would require seven years to raise completely matured sponges fit for the market.

EXPERIMENTS IN FLORIDA.—It has been maintained, however, that for Florida sponges the rate of growth is considerably quicker than that indicated by these experiments, and the only account yet given of any attempt there made to grow sponges from cuttings appears to confirm this view. This is given by Rathbun,* as follows—

---

* *Loc. cit.* p. 832.

"The first trials were made at Key West, by the agent of Messrs. McKesson and Robbins, sponge dealers, of New York, who have recently contributed to the U. S. National Museum four specimens of the sheepswool variety, showing the first-fruit of this important work. We have not been able to obtain a detailed report of these experiments, but from a letter written at Key West, and kindly furnished by Messrs. McKesson and Robbins, the following brief account has been prepared—

"The sponges were all raised from cuttings; the localities in which they were planted were not the most favourable for sponge development, and their growth was, therefore, less rapid and perfect than might otherwise have been the case. They were fastened to the bottom, in a depth of about 2½ feet of water, by means of wires or sticks running through them. The four specimens sent to Washington were allowed to remain down a period of about six months before they were removed. Fully four months elapsed before they recovered from the injury done them in the cutting, which removes the outer 'skin' along the edges of the section, and the actual growth exhibited was for about two months only. The original height of each of the cuttings was about 2½ inches. One was planted in a cove or bight, where there was little or no current, and its increase in size was very slight. The other specimens were placed in tide-ways, and have grown to from four to six times their former bulk. Two hundred and sixteen specimens in all were planted at the same date, and at the last accounts those that remained were doing finely.

"The chief obstacle to the artificial cultivation of sponges at Key West arises from the fact that the sponge fishermen infest every part of the region where sponges are likely to grow, and there is no legal protection for the would-be culturist against intruders. The enactment of judicious laws bearing upon this subject by the State of Florida, or the granting of special privileges conferring the right to occupy certain prescribed areas for sponge propagation, would undoubtedly tend to increase the annual production of this important fishery."

Unfortunately, these experiments do not appear to have been carried further in Florida, and no reference to their continuation is made in subsequent reports of the U. S. Fish Commission.

MEMORANDUM BY MR. BENEDICT.—Through the kindness of Professor Brown Goode, it is possible in this connection to add the following memorandum by Mr. James E. Benedict, Assistant Curator of the Department of Marine Invertebrates at the United States National Museum—

"While in Florida several years ago, I inquired particularly into sponge culture. Many people denied that the experiment had ever been successfully tried, showing that it had not been tried to any great extent. I was informed, however, that by raising a sponge nearly to the surface, without lifting it out of the water, and dividing it up, and fastening the pieces to some anchor, and placing them in favourable localities, they grew rapidly. The sponge fishermen, however, are very much opposed to experimenting in this direction, as they believe it can only be successfully carried on when the grounds are parcelled out, which they think would result in monopoly, and cutting off their means of subsistence.

(Signed) "JAMES E. BENEDICT,
"*Assistant Curator, Department of Marine Invertebrates.*
"November 14*th*, 1895."

WOULD SPONGE-CULTURE BY CUTTINGS BE PROFITABLE?—To what extent the culture of sponges, after the manner suggested by Schmidt, would be a profitable undertaking, depends largely upon the rate of growth of the cuttings as compared with the rate of growth of uncut sponges. As Dr. von Marenzeller points out, it is questionable "whether it is profitable to cut to pieces a sponge, which uncut would have quicker reached the same size and weight than all the cuttings together in seven years. Under such circumstances, sponge-culture had better be confined to the transformation of flat and, therefore, worthless sponges into round ones, which, though small, would find a ready market. Possibly several, especially misshaped, pieces might be made to grow together, and form larger and better ones."

SUGGESTED EXPERIMENTS.—Mr. George Bidder, a member of the Marine Biological Association who has been engaged for some years in studying the anatomy and physiology of sponges, and is a recognised authority on these subjects, has kindly furnished some valuable notes upon this point, in addition to a number of suggestions as to various methods for endeavouring to improve sponge fisheries, which are appended to this report.

In addition to the practical proposals made by Mr. Bidder as to the most suitable lines upon which experiments might be carried on, with a view to the improvement of the Bahama sponge industry, it may be suggested also that, in case this has not already been tried, an attempt should be made to obtain sponges in the Bahamas from deeper water, either by the use of the dredge, or with the aid of divers. In the Mediterranean, the sponges found in shallow waters, such as those from which they are obtained in America, are stated to be much coarser and less valuable than those taken from depths of from 15–20 fathoms. According to Hyatt, sponges probably occur in American seas down to a depth of about 30 fathoms, and it is quite possible that an attempt to obtain some of those living at greater depths than the 3–6 fathoms, to which the fishing is at present confined, might yield more valuable material. This could be easily ascertained, when one of H.M. ships, with divers on board, visited the Bahamas, or experiments might be made with the dredge. Sponges obtained by these methods would also be less injured than those taken with the hooks.

Note on Projects for the Improvement of Sponge-Fisheries.

By

George Bidder.

For Summary see under title of preceding article.

A. *Sponge-cultivation.*

In considering the experiments of Buccich (6) on propagation of sponges by cuttings, two main questions present themselves:—

(1) If a sponge be divided into many fragments, will the total increase of such fragments and their progeny be greater than the increase of the intact sponge and its progeny would have been in the same time; the conditions of water, &c., being identical?

(2) Are sponges, grown as recommended by Buccich, more or less favourably situated than those on the sea-bottom?

(1) The first of these questions I should, according to our present knowledge, answer in the negative. We have no evidence whatever as to the rate of growth of the sponge of commerce at Lesina, under natural conditions. So far as I am aware, there is no observation in the literature of the subject which throws any light whatever on the probable age of sponges of given size, their probable future rate of increase, or the dimensions at which increase stops.*

When, therefore, Buccich records that his cuttings grew to two or three times their size in the first year, we have no reason for supposing that an equal increase would not have taken place had they remained intact in the surface of the parent sponge. *A priori*, I should suppose that a greater increase would have taken place. For the life of a sponge depends on a most interesting system of hydraulic canals, on the mechanical perfection of which depends the quantity of its food. Each cutting contains only the fragment of such a system, broken into, with direction of currents confused or inverted, and pressure-chambers opened. Until growth has repaired these injuries, the cut fragment must necessarily be at a disadvantage, as compared with a complete sponge of its own size,* and I am of opinion that the complete small individual is at a disadvantage as compared with the equal portion of a large and powerful sponge.

---

* A discussion of the question of growth will be found in the Appendix.

We have no knowledge of any causes to check the growth of a sponge, though it may be assumed (without positive proof) that they are subject to senile decay. But we have no knowledge that the tissues of a senile sponge undergo rejuvenescence when they are divided into fragments; and the observations of Buccich—that certain cuttings never grew at all, and that the growth was unequal—indicate slightly the more probable hypothesis that the fragment of an effete sponge is itself effete.

It is urged that misshapen sponges may thus be utilized. But it must be pointed out that misshapen sponges can still breed, and that there is no evidence how far the reproductive function is interfered with by the cutting process; I should myself expect such interference to be important. Buccich found 90 per cent. of his cuttings attain "marketable size" in seven years. Whether this is advantageous depends on the length of time taken by a self-sown sponge to attain "marketable size." If this be seven years also, then the method is profitable for misformed sponges; if it be only one year, then the quantity produced by natural reproduction would be greater than by the method of cuttings.

I know of no observations which favour the former hypothesis; and some siliceous sponges have been observed to grow to an equal size in a single season.

In view of the commercial importance of this question, it appears highly desirable that observations should be made as to the rate of growth of self-sown sponges. Until such are made, I cannot see that we have any reason to suppose that propagation by cuttings is in itself likely to increase the value of a sponge field.

(2) The above conclusion coincides nearly with that of Dr. von Marenzeller, in 1878. But the second question appears to have escaped his notice.

Briefly, I consider that the method of Buccich may possibly be made useful as a means of inducing sponges to grow on a more extended surface than the sea-bottom, and under more advantageous conditions.

It has been recognised among certain littoral sponges that gigantic specimens are generally found hanging from the under surface of a rock, or floating body.* This has been observed for calcareous sponges on the floating frameworks set for oyster-spat in Holland (9), on the bottoms of ships in Naples harbour (9), on the under surface of a buoy at the Isle of Man (**13**), and may be verified to some extent even on the shore-rocks near the Plymouth Laboratory.

---

* In the Florida experiments it is recorded that this was the case.

I am aware of no direct observations on this point with regard to any greater depth. But the same advantage, probably, there also attends an elevated position. Thus, Hyatt (5) says that "The sponges near Nassau lie . . . . always in currents, sometimes running three or four miles an hour. . . . . Both of these conditions are essential to sponge growth, namely, a continuous renewal of aërated water, and a plentiful supply of food." And Rathbun (**11**) says of cuttings in Florida: "One was placed in a cave or bight, where there was little or no current, and its increase in size was very slight. The other specimens were placed in tide-ways, and have grown from four to six times their former bulk."

Now, where a current of water is flowing over a solid surface, a very slight increase in height from the surface means great increase in velocity of current. Buccich's method placed the cuttings from four to twelve inches above the sea bottom, and with their centres four inches apart, disposed on four parallel gratings separated from each other by the same distance. He appears to have dealt only with the small, fine, toilet sponge (7); but even so, I think the system capable of improvement. I consider great advantage might be obtained by inducing sponges to grow on hurdles rising some feet above the sea-bottom, and allowing a distance between the centres of four inches for cuttings, and twelve inches or more for grown sponges, with a distance between every two hurdles equal to their own height. I should experiment by ballasting and sinking a hurdle such as is used for a deer fence, preferably of enamelled iron; with *(a)* canes tied across it parallel to the bars, and *(b)* vertical tiles, hung in pairs on the bars. To these cuttings, or small sponges, might be attached; and I should try making the attachment with a needle and thread, using the method of Buccich as a control experiment. The cuttings on the canes would grow round them to form perforated spheres. These Marenzeller states to be of less value in the market, owing to the perforation, but I should imagine they would soon acquire a value of their own, as they would have no torn surface. These, also, as being exposed on all sides, would probably grow most rapidly. The cuttings on the tiles should become of the ordinary hemispherical type. It might be found that young sponges would sow themselves naturally on the tiles, rendering cuttings unnecessary.

---

* Cf., especially VOSMAER (9), where he points out the advantages to the sponge of a position where water flows freely round it. This was to some extent recognised, long ago by Grant *fide* Johnston (1).

It would be better if the hurdles were sunk rather in deeper water than that from which the sponges are taken, lest the cuttings should suffer from excess of light. I should cut the sponges in a wooden trough, holding enough water to cover the sponge. The advantages expected by the method would be :—

(1) Increase of the bearing area of the field.
(2) Removal of the sponges without injury, and with careful selection.
(3) Increase in the rate of growth, and in the maximum size.
(4) Improvement in shape of the sponges.

There is also a proposition given by Dr. von Marenzeller which deserves attention. Larger sponges are naturally of greater value, in proportion to their weight, than smaller sponges; and he points out that if two or three be attached closely together (misshapen specimens could be thus utilized) they will grow into one sponge.

In this case, also, I should suggest the use of the needle and thread to effect the attachment; and, from the biological point of view, there is little doubt of effectual union. But the possible existence of biological disadvantage, in total ultimate weight, cannot be estimated until we have some knowledge of the laws of growth in sponges; and the commercial advantage depends not only on this, but on market details, as to which I cannot find information. Probably the increase in value with size of Nassau sponges is far less than with those of the Adriatic.

It must be understood that these recommendations are based principally on general reasoning from what is known of the conditions of life in sponges. The direct experimental evidence bearing on the questions involved is slight, imperfect, and uncertain; the work done by Professor O. Schmidt (6) was brilliant; but it has remained incomplete, as he left it, for twenty-three years.

To avoid needless waste of capital, it is desirable to make a series of exact observations on the sponge of commerce with regard to the following points :—

(1) Rate of growth, and length of life, of sponges growing naturally on the sea-bottom.
(2) Do. do. of sponges attached with their natural bases to artificial trestles or hurdles.
(3) Do. do. of sponges raised from cuttings in either position.
(4) The size at which, in self-sown sponges and in cuttings, breeding commences.

It must be remarked that it is difficult to see how any process of culture can be possible, unless private property in areas of sponge-fishery can be recognised and protected. [*Cf.* (1) (6)].

I see that Mr. Allen properly suggests the possibility that the deeper waters of the Bahamas may with advantage be exploited. If this be done, as in the Mediterranean, by divers without diving dresses, I would suggest encouraging them to try the use of water-spectacles. I am not aware that these have been ever used either for pearl-fishing or sponge-fishing; but, while every student knows that the imperfection of the submerged human eye can be corrected by convex lenses, there is a wide gulf of ignorance separating the student from the pearl-diver of the Indian Ocean. Probably any wholesale optician would supply spectacles of the required formula at the price of a few pence. The experiment might be worth instituting at Ceylon.

B. *Transport of Sponges from the Mediterranean to the Bahamas.*

If it were desired to transport European sponges alive to the Bahamas, I believe that this could be done. The sponge of commerce lives well in the Naples Aquarium, and I see no reason why it should not live in a suitably constructed tank on board a ship. In this way a number of individuals might be transported, and deposited in a space cleared from other sponges at a spot where the fishery is good, there to breed as they successively ripened. If it were practical from the nautical point of view, I should suggest the use of a closed wooden tank, with perforated sides, flat bottom, and pointed ends, to be towed behind the ship; just floating enough to keep a flagstaff out of water in case of accident. The sponges should be gathered with the pieces of rock to which they adhere, and these stones fixed firmly in the bottom of the tank. Before employing this method, it might be prudent to make aquarium experiments as to how far the high surface temperature of the seas traversed may prove deleterious to the sponges. Were such temperatures proved to be fatal, it would be necessary to use an aquarium inside the ship, artificially cooled.*

---

* Since the text was in type, I have been able to consult Lamiral's original account (3) of his unsuccessful attempt, in 1862, to acclimatise Syrian sponges on the French coast. He placed 150 sponges in six cubical boxes of 2 ft. 7 in. each way, six similar boxes being used for reservoirs to maintain a circulation (cooled with such ice as he could obtain), and the whole carried on the deck of a crowded packet-boat. This apparatus was quite inadequate; and his description leaves little room for doubt that the tanks were lined with bacterium slime from the very beginning of the voyage, and that the sponges hopefully planted on the French shore were in various stages of putrescence.

He records the bottom temperature at Tripoli in May as 19° C. in ten fathoms of water; his reservoirs on the journey rose to 23° C. and 25° C. An interesting account of the Syrian divers is given; besides useful details as to qualities of sponges, &c.

But if the transport were successful, and the sponges bred, it is very doubtful if any advantage would be gained. It must be regarded purely as an experiment in the dark; and I can see no means of forecasting its result, or testing it in any way, but by its completion. If the difference between the sponges is a true racial difference, then the race from the Mediterranean might possibly prove stronger than the race of the Bahamas, and supplant it, though the fact that the climates are different is against considering this as probable. There is, however, grave doubt whether the difference be due to deep-seated heredity. The sponges of America are considered no more than varieties of the Mediterranean species; and Professor Hyatt is of opinion (5) that the difference in quality between American and European sponges is due to the higher temperature of the American water, and to the coral sand. My own experience in calcareous sponges points to most remarkable plasticity in response to changes of environment, and it must be considered possible that, even if the imported sponges bred, their offspring would be indistinguishable from those always existing in the locality.

C. *Close time for Sponges.*

It is so common and so natural a tendency to consider the well-being of any fishery capable of improvement by the imposition of a close season, that it may be worth while recording simply that, according to F. E. Schulze (7), the toilet-sponge at Lesina breeds quite indifferently all through the year.

Professor Schulze is the leader of all modern work on sponges, and his observations were made on a plentiful series of sponges supplied by Signor Buccich.

APPENDIX.

Rate of Growth in Sponges.—According to T. Leo (12), the fishermen of Nassau say that the young sponge reaches marketable size three months after its attachment. Lamiral (3), in his scheme for acclimatisation on the French coast, stated that exhausted fisheries are regenerated in three years.* O. Schmidt (6) "inclined to the opinion" that the growth of a self-sown sponge was no faster than that of one of his cuttings, which were found to take seven years to reach marketable size;—it is noticeable that before the experiment he had expected quicker growth (*l.c.* p. 776). The Florida fishermen—*v.* Rathbun (11)—contend that "the Florida sponges grow much more rapidly, and reach a fair size within a comparatively short period." The Florida cuttings increased "to from four to six times their bulk" in six months, but this growth was actually effected in two months, as "fully four months elapsed before they recovered from the injury done them in the cutting."

If this last be accurate, then a cutting of 2½ cubic inches, growing to five times its bulk in two months, attained a volume equal to a hemisphere over 3½ inches in diameter. Were it to proceed for the next two months at the same rate, we should have a hemisphere over 6 inches in diameter, which is more than marketable. Had the original 2½ cubic inches been produced at the same geometric rate, then a hemisphere of 1¼ inches in diameter would have produced the six-inch sponge in six months.

We have no right to assume this constant geometric ratio, nor to reason elaborately from inexact statements about amputated fragments; but putting these observations with the assertions of the Nassau and Florida fishermen, there seems a balance of evidence against assuming in these localities a period much greater than a year before the self-sown sponge becomes marketable. The Levant variety, discussed by M. Lamiral, lives where the atlas shows a mean annual temperature of about 7° F. below that of Florida, and the Adriatic variety, investigated by Professor Schmidt, at a mean temperature of about 7° F. lower still; we have no right to assume that the rates of growth are identical. But since in the Adriatic the same grounds are said (8) to be fished mercilessly, mature and immature, year after year,† there seems to be great presumption against Schmidt's estimate; and this estimate was calculated from Buccich's cuttings, which I believe to have been unnecessarily injured by exposure to air, by the trepanned perforation, and by too close planting so as to choke each other.

---

* "On ignore quelle est au juste la durée de la vie des Eponges et la vitesse de leur accroissement; cependant, dès la troisième année, on peut revenir pêcher dans les lieux où elles avaient été précédement presque épuisées."—LAMIRAL, *loc. cit.* vol. viii. p. 329.

† Probably based on Schmidt's own statement: "Man sucht in der schon beschriebenen Weise dieselben Standorte Jahr für Jahr ab. . . . nicht nur die ausgewachsenen, sondern auch die kleineren Exemplare genommen werden." (Supplement der Spongien der Adriatischen Meeres, 1864, p. 25.) At the time of writing the text I could not refer to Schmidt's original papers; there is nothing to be added from them to the later account of his experiments given by Marenzeller.

The much-needed observations on the natural growth of commercial sponges could probably be best made by observing the seedlings on a small marked area, artificially cleared. Single sponges fixed on stones could also have labels attached with silver wire, and be examined periodically.

That the rapid period of growth suggested by the fishermen is not impossible, is shown by a few observations which have been made on calcareous and siliceous sponges. Vosmaer (9) calculated the giant *Sycon* on the oyster-frames to grow 1 to 2½ inches in length in a fortnight, and (10) found the bud of a *Tethya* in a month as large as its mother, ⅘ inch in diameter. Bowerbank (4) quotes H. Lee, that in the Brighton Aquarium *Hymeniacidon* formed in five months a crust 1 foot in diameter. Of this sponge and of *Halichondria* numerous large crusts may be observed in spring on the rocks near Plymouth Laboratory; they appear rarely to survive the summer, and Johnston (1) states that many allied species are annual. Carter (2) found *Spongilla*, at Bombay, grow over a surface two or three feet in circumference in nine months; and states that specimens growing on straw in the water reached a thickness of half-an-inch in a few days, before the straw in the water had changed colour.

The growth of horny sponges may easily be much slower than in these instances, but as yet I know of no reason to assume so.

REFERENCES TO QUOTATIONS.

1. Johnston, G. (1842).—"History of British Sponges and Lithophytes," p. 92 and p. 124.
2. Carter, H. J. (1849).—*Annals and Mag. Nat. Hist.* pp. 95 and 96.
3. Lamiral, E. (1861–1863).—*Bull. Soc. d'Acclim. Paris*, vol. viii. p. 327; vol. ix. p. 641; vol. x. p. 8.
4. Bowerbank, J. S. (1874).—"Monograph of British Spongiadæ," vol. iii. p. 339.
5. Hyatt, A. (1875 and 1877).—*Mem. Boston Soc. Nat. Hist.* vol. ii. quoted here from "U.S. Fish. Comm.," "Fishery Industries" (4to.), Sect. i. pp. 845, 846.
6 Marenzeller, E. von (1878).—*Verhandlung der K. K. Zool. Bot. Gesellschaft in Wien*, quoted here from translation in "U.S. Fish. Comm. Report" (8vo.), 1879, p. 771, *et seqq.*
7. Schulze, F. E. (1879).—*Zeitschr. wiss Zool.* vol. xxxii. p. 617 and p. 642.
8. Faber, G. L. (1883).—"Fisheries of the Adriatic," p. 96.
9. Vosmaer, G. C. J. (1884).—*Mitth. Zool. Stat. Neapel*, vol. v. pp. 486 and 487.
10. Vosmaer, G. C. J. (1887).—"Bronn's Klass. u. Ord. d. Spongien," p. 440.
11. Rathbun, R. (1887).—"U.S. Fish. Comm., Fishery Industries" (4to.), sect. v. vol. ii. p. 832.
12. Lee, T. (1889).—"U.S. Fish. Comm., Report of Comm. for 1886," p. 664.
13. Browne, E. T. (1894).—*Trans. Liverpool Biol. Soc.* vol. viii. p. 45.

It will be seen from this list how greatly I have been aided in compiling these notes by the most valuable publications of the United States Commission of Fish and Fisheries.

Recent Reports of Fishery Authorities.

The Scottish, Newfoundland, and United States Reports.

By

J. T. Cunningham, M.A.

(1) Thirteenth Annual Report of the Fishery Board for Scotland, being for the year 1894. Edinburgh, 1895.

(2) Annual Report of the Newfoundland Department of Fisheries for the year 1894. St. Johns, N.F., 1895.

(3) Report of the United States Commissioner of Fish and Fisheries for the year ending June 30th, 1893. Washington, 1895.

ARTIFICIAL HATCHING OF FISH EGGS.—The Scottish Report, whose title is given above, is stated to refer to the year 1894; but as a matter of fact, a great deal of the work recorded in it was carried out during the earlier portion of 1895. This is the case with the operations of the Dunbar Hatchery, described by Mr. Harald Dannevig, the Manager of that establishment. We find that 44,085,000 eggs of plaice were collected last spring, and from these 38,615,000 fry were obtained, and liberated in the sea. This shows a loss of only 12 per cent. in the process of hatching. But large as the numbers appear, it should not be forgotten that the above number of eggs represents the produce of only 220 female fish, reckoning 200,000 eggs to each, which is a low estimate, for it has been proved by Dr. Fulton that the larger female plaice produce each from 300,000 to 500,000 eggs in one season.

It is, I think, interesting to consider, from various points of view, the proportion borne by the artificial hatching operations to the natural propagation of the fish in the sea. We have not at present ascertained approximately the number of females which spawn in the sea in one season, but we have some data concerning the number of mature females taken out of the North Sea, in one year, by the fishermen. According to Mr. Holt's statistics, which were very carefully collected, the number of mature plaice, over 17 in. in length, landed at Grimsby alone in one year is more than 7,000,000; and as there are three females to two males, we may reckon that over 4,000,000 of these are females. We take, then, 4,000,000 of mature female plaice from the North Sea at Grimsby alone, not to speak of the numerous other trawling ports on the east coast of Britain, and in return we hatch the eggs of 220. The proportion here is one spawner in the hatchery for every 19,090 spawners killed at Grimsby. But next we have to take into consideration the superiority of the artificial process. We do not know what is the mortality of the eggs and fry in the period between fertilisation and the absorption of the yolk, under natural conditions. As we have seen, in the hatchery the mortality is only 12 per cent. Let us assume, for the purposes of calculation, that the loss is only 10 per cent. in the hatchery, and is 90 per cent. in the sea. Then we obtain nine times as many fry in the hatchery as in the sea from the same number of fish. It comes to the same thing if we say that one female spawner in the hatchery is equal to nine spawners shedding their eggs, without assistance, in the sea. We may say, therefore, that the work of the hatchery is equivalent to saving 9 females out of every 19,090 landed at Grimsby, or one out of every 2,121, or, in round numbers, one out of every 2,000. The disproportion would be very much greater if we took the total number of female plaice landed on the east coast of Britain. It seems to me beyond question, that if we regard the whole North Sea plaice fishery in this way, not taking the numbers caught by foreign fishermen into account, the results produced by the operations at Dunbar will be quite imperceptible. To diminish the destruction of mature fish even by one in every 2,000 in each year, could not make any appreciable difference in the general abundance of plaice in the North Sea.

It must not be supposed that I have any prejudice against artificial hatching, or that I am unable to appreciate the skill and efficiency with which the Dunbar establishment has been organised and operated. On the contrary, I think that Dr. Fulton and Mr. Harald Dannevig deserve great credit for the energy and ability they have exhibited in the working of the first British hatchery for sea-fish, and for the success they have obtained. No harm, but only good, can result from an honest and strictly accurate calculation of the possible results. The evidence available from other enterprises of the same kind tends to show that quite obvious local results have been produced by the liberation of large numbers of fish-larvæ in the sea, and although, as the above calculations show, we cannot expect to perceive any increase in the general plaice production in the North Sea, in consequence of the work at Dunbar, it may be quite possible to recognise on particular local grounds an increased abundance of marketable plaice, derived, with reasonable probability, from the fry liberated from the hatchery. We cannot, however, admit the correctness of certain calculations contained in the official general statement of this Report. These are, that if one in a hundred of the fry distributed from the hatchery survived, and were worth sixpence each, the resulting value to the fisheries would be about £18,000, and that it would require the survival of only one in a thousand, in value one penny each, to cover the expenses of the work. Fish in the sea have clearly no value, and we cannot hope to catch all of them. It is difficult to say whether a quarter, a half, three-quarters, or what proportion would be caught; but even when they were caught and sold, their value could not be all applied to defray the cost of hatching, because the greater part of it, as usual, would go to defray the cost of catching and marketing. Such calculations would only be applicable to fish that were reared entirely in confinement, like chickens or pigs.

The importance of the working of a marine hatchery at the present time, and on the comparatively small scale of that at Dunbar, may be reasonably held to be, not in the immediate utilitarian result to be derived from it, but in its value as a sufficiently extensive experiment in the open. We have reached a certain point in laboratory research and experimentation. We have discovered enough concerning the life-histories of food fishes, and their place in nature, to obtain glimpses of the possibility of a more scientific and more profitable exploitation of the products of the sea than that which is now practised. To convert these glimpses into comprehensive perception, we require more investigation and experimentation under the open sky, and on a scale commensurate with the extent of the regions to be exploited. Thus the managers of a hatchery ought not be content with proclaiming the millions of fry they have liberated, but should ascertain what ratio these numbers bear to the number of fry naturally present in the region where they are placed, and should make every endeavour to trace their future history. In this Report Dr. Fulton gives the result of some very valuable experiments he has made, as to the effect of the currents on the east coast of Scotland, on bottles floating level with the surface. These results show that buoyant objects at the surface are carried southward and eastward to the neighbouring shore. One or two of these bottles were found ultimately on the German coast, near Heligoland. The fry from the hatchery were liberated at the mouth of the Firth of Forth, and in St. Andrew's Bay, and according to the direction of the drift, ascertained by the experiments just mentioned, the survivors should be found chiefly on the southern shores of the Firth, and further south-east towards Berwick. It will probably turn out, therefore, that the influence of a hatchery is confined for the most part to a comparatively limited neighbourhood, and it ought to be possible, if the necessary data are accurately observed, to ascertain the magnitude of its influence within these limits. Comparisons should be made between the natural propagation of the fish, and the artificial propagation within the limits thus set by natural conditions. Hitherto they have not been made, and the necessary observations have not been carried out. The results would doubtless be more favourable than those of the comparison above made between the operations of one hatchery and the Grimsby fishery.

In the Newfoundland Report for 1894 it is stated that the number of cod eggs treated at the hatchery, on Dildo Island, Trinity Bay, in that year, was 346 millions, from which 221½ million fry were obtained and liberated. This is a survival of 64 per cent., or a loss of 36 per cent. The number of cod fry liberated was, therefore, nearly six times as great as that of the plaice-fry produced at Dunbar. But it must be remembered that the cod normally produces a much larger number of eggs than the plaice. According to Dr. Fulton's calculations, the number in the cod varies roughly between three and six millions. If we take four millions as a moderate average, the above number of eggs is the produce of only eighty-six female cod, so that from this point of view the work of the Dunbar Hatchery on the plaice was really of greater magnitude than that of the Newfoundland Hatchery on the cod. The efficiency of the treatment was considerably greater at Dunbar, that is to say, the loss or mortality during the treatment was much less in the Scottish establishment. But at Dildo Island the number of eggs collected was so large that there was not room for all of them in the hatching apparatus, and the excess was utilised by being placed in linen bags, suspended in wells, in the wharves outside the hatchery. This may to some extent account for the greater percentage of loss.

As evidence of the successful results of the hatching operations in Newfoundland, it is stated that in the beginning of the summer of 1894 there was a great abundance of cod of various sizes and ages in Trinity Bay, and none in the neighbouring Bonavista and Conception Bays, where the season's fishery turned out very poorly. The liberation of fry has been carried out annually since 1890 in Trinity Bay only, and it is maintained that the cod found in large numbers in that bay in 1894 were derived from the fry deposited. It is stated that the cod one year old were most abundant, next to these in numbers were cod of two years, and then the three-year-old fish, with a fair proportion of still older and larger fish. This is in accordance with the continual increase in the number of fry liberated each season since 1890.

In the Newfoundland Report for 1892 it is pointed out by Mr.

Nielsen, who conducts the hatching operations, that the idea that if the fish were not artificially treated they would propagate in the natural way, is a mistake. All the spawners are caught in the neighbourhood of the hatchery, and if there was no artificial hatching just as many fish would be taken, and no living fry would be returned to the sea from them. We here come upon the same question which was indicated above, in reference to the Dunbar Hatchery, namely, what proportion exists between the number of spawners artificially treated, and that of those which spawn naturally in the same district. Evidently Mr. Nielsen's view is that the capture of adult fish is so great that very few are left to shed their spawn, or, at any rate, such a small number that the number of the fry derived from them is small in proportion to the number of fry liberated from the hatchery. We cannot deny that the evidence given of the great increase in the number of adult cod, following directly upon the liberation of millions of fry from the hatchery, gives strong support to Mr. Nielsen's contention. But in this, as in other cases, we ought to be supplied with other important evidence, perhaps the most important being a direct determination of the number of cod eggs actually present in Trinity Bay, during the spawning season of the cod, in order that we may compare this with the number of eggs treated artificially in the hatchery. In Newfoundland, as in Norway, it has been observed that an increase in the supply of cod has followed upon artificial hatching. But in regard to all such evidence the vastness of the numbers put forward, and the absence of accurately observed data for comparison, tempt one strongly to adapt a well-known phrase and say, "c'est magnifique, mais ce n'est pas la science." The operation which is stated to produce such successful results, is that of placing so many million living fry in the sea at the stage at which the yolk has just been all exhausted. Surely it is not impossible, or even difficult, to ascertain how many such fry were in the sea already, without the operation. Until this or similar facts have been ascertained, it cannot be said that the process of artificial propagation has been put on a practical basis.

However, notwithstanding this criticism, it must be admitted that local benefit from artificial propagation appears to have been produced. This leads to some further interesting considerations. It is well-known that the Scottish Fishery Board have closed certain inshore areas to beam-trawling. In these areas there appears to be no kind of fishing carried on which involves the destruction of young plaice or the young of other flat fishes on a large scale. The abundance of the flat fishes in these closed areas has been examined annually since 1886, with great statistical accuracy, by means of experimental trawlings carried out by the Board's steamer *Garland*. Notwithstanding the protection, the number of plaice and other flat fishes has not increased: it has fluctuated from year to year, but never maintained a steady increase. The number per haul of the trawl has also not increased in the open area.* It seems reasonable to infer that the reduction of the number of spawners on the open grounds, by the great extension of the trawling industry, is so great that protection of the young fish is not sufficient to compensate for it. With food-fishes, as with oysters, we are apt to attach so much importance to the number of ova produced by each female, that we overlook the importance of the number of females. It is of course true that if we could save a larger proportion of the progeny of a few parents, we should obtain a large number of fish or oysters. But, on the other hand, it may be, and experience indicates that it would be, more practicable to obtain our object by preserving a larger number of parents. In the case of oysters more success has been secured, as Mr. Bashford Dean has pointed out, by maintaining a very large reserve of parents, than by trying to preserve a larger proportion of the progeny. One method of doing this with sea-fishes would be to create reserved and protected spawning grounds. But there are objections to this method: there is the difficulty of protection, and also the fact that the fish will wander away, and be caught on other grounds. Now it is possible to regard the hatchery, as at present worked, as simply a reserve of spawners. No matter how many spawners may be taken from the sea, those in the hatchery are safe, and will supply their annual quantum of eggs or fry. But to carry out this principle effectively it would be necessary to keep in confinement, not hundreds but thousands or millions of spawners. We should have to maintain a number bearing some significant proportion to the number which now survive to spawn in the sea. It is conceivable that if spawning fish were maintained in confinement all along the coast in sufficient numbers, we might depend for our fish supply almost entirely on the eggs and fry derived from those. It may be that this will be the ultimate solution of the problem of replenishing our exhausted fishing grounds. In the meantime, although it seems wonderful to read of hundreds of millions of fry placed in the sea, as a matter of fact we are dealing, as I have shown, with only a few hundred spawners, while thousands upon thousands are being annually captured.

---

* The following are the average numbers of fish taken per shot of the trawl, in two periods of four years:—

	CLOSED AREA.		OPEN AREA.	
	Flat fish.	Round fish.	Flat fish.	Round fish.
1886–89 . .	178·5 ...	77·8	91·2 ...	86·4
1891–94 . .	120·9 ...	89·9	77·6 ...	102·5

In the American Commissioner's Report (p. 72), we find a section devoted to the description of "Some Results of Acclimatisation." The most important of these results is the successful introduction of the Atlantic shad (*Clupea sapidissima*) to the waters of the Pacific coast of North America. The supply of shad on that coast, we are told, continues to increase, and is now so great that the retail price of the fish there is actually less than on the Atlantic coast. The shad has within a few years not merely been successfully introduced, but has permanently established itself, and become one of the cheapest fish of the region. It must be noticed, however, that this is not, properly speaking, a success to be placed to the credit of the system of artificial propagation. It is true that the introduction was effected by the transportation of artificially hatched fry from hatcheries on the Atlantic seaboard, and their liberation in Pacific waters. But the abundance of the fish in the Pacific States is due to its own natural multiplication in its new habitat, not to its continued artificial propagation there, and the same success might possibly have been obtained if a sufficient number of adult fish had been placed alive, and in healthy condition, in the rivers of the Pacific slope. The transportation of the minute fry may have been easier than that of the adult fish ; perhaps, indeed, the latter operation would not have been possible at all. But even if this were so, the artificial hatching of the fry, in the first instance, was only a detail in the process of transportation and introduction, and artificial propagation has not been carried on subsequently in the new habitat, and therefore has had nothing to do with the subsequent increase in the supply, any more than artificial breeding has had to do with the troublesome multiplication of European rabbits in Australia.

The introduction of shad fry to the rivers of the Pacific States was first attempted in 1871, 24 years ago, when 12,000 of them were liberated in the Sacramento River. From that year until 1886, 609,000 fry were liberated in the Sacramento, 600,000 in the Williamette River, 300,000 in the Columbia River, and 10,000 in Snake River. Nothing is said of any planting of fry after the year 1886. The catch of the fish in 1892 was estimated at 700,000 lbs., having a value to the fishermen of £4000. But, probably in consequence of thinness of the population, the demand for shad in the west seems very slight, the price in 1892 being 4 cents. or 2d. a lb., and the fish being only incidentally taken in nets operated for salmon, or other fish. This fact has, doubtless, an important bearing on the increase in the abundance of the shad. The remarks I have made show how completely illogical, in my opinion, is the argument contained in the following sentence, quoted from the Report under review: "If these far-reaching and no doubt permanent results attend the planting on few occasions of small numbers of fry, in waters to which the fish are not indigenous, is it not permissible to assume that much more striking consequences must follow the planting of enormous quantities of fry year after year, in native waters?"

The history of the introduction of the striped bass (*Roccus lineatus*) to the same region adds strong support to my argument, for this introduction was altogether independent of artificial propagation. In 1879 about 150 specimens, a few inches long, taken in Shrewsbury River, New Jersey, were carried across the Continent and liberated at the mouth of Sacramento River; in 1882, another lot of 300 fish was transported to the same region. As a result of these two small deposits the species became distributed along the entire coast of California, and the catch in 1892 was about 43,000 lbs., for which the fishermen received somewhat more than £1,000.

The operations of the U.S. Commission for the year, in the propagation and distribution of fish, are recorded in the Report in great detail, but only a few points need be mentioned here. The discussion of results is not attempted in this section of the Report. The propagation of marine fishes is still conducted on a rather small scale. At Gloucester Station, Mass., 49 million cod eggs were obtained, and 20 million fry produced and liberated. At Woods Hole cold killed the spawners, and only 2,883,000 cod eggs were obtained, from which 850,500 fry were produced. Lobster eggs were also hatched; and mackerel, sea-bass, and flat fish on a very limited scale. Of shad 31 million fry were hatched at Battery Island Station on the Chesapeake, about 7 million on the Delaware, 5½ million at the Central Station, a total of 43½ millions. Thus, the number of fry obtained was only a little greater than that of the plaice hatched at Dunbar, and little more than one-fifth of the number of cod-fry hatched in Newfoundland. But, on the other hand, the number of eggs per female shad is given as 45,000, and the number of eggs obtained was 74,150,000, so that 1,647 females were stripped, and from this point of view the propagation of shad in the United States, is on a larger scale than that of plaice or cod in Scotland or Newfoundland.

INVESTIGATIONS.—As usual, a considerable amount of research is described in the Scotch Report. Dr. Fulton has added another series of experiments to those which have been carried out on the *Garland*, by his instructions. In this case he has had an equal number of hooks of different sizes fitted on one long line, and the line has been shot, in order to see whether the larger hooks caught fewer small and immature fish. The fish caught in largest numbers were of course haddock, and although the proportion of mature to immature fish was greater with the larger hooks, still this advantage was not sufficient to compensate for the great general reduction in the number of fish caught. Small hooks catch a large proportion of large fish, and large hooks a considerable proportion of small.

Of Prof. McIntosh's additional contributions to the knowledge of eggs and larvæ, perhaps the most interesting is that concerning the turbot. The material in this case was derived from the mature living turbot, collected at the Dunbar Hatchery. In the summer of 1894, these turbot, although gravid, did not spawn. On the 7th September a specimen was examined, and in the centre of the enlarged ovary was a large space filled with mucus and the remains of ripe, but dead, ova. The fish were evidently, it is stated, getting rid of the eggs of the season which had been retained in the ovary, and died there. This is exactly what I described years ago, in this Journal, concerning the sole in the Plymouth tanks. Prof. McIntosh thinks that the egg-bound condition, *i.e.* the refusal to shed the spawn in a normal manner, is voluntary, and that it would soon disappear when the fish grew accustomed to confinement. It is quite probable that the turbot would shed its spawn in confinement after a time, but in the Plymouth Aquarium the soles did not spawn till after five or six years, and the turbot has not spawned there yet. At Dunbar, the soles and turbot collected in 1894 were unfortunately lost from overcrowding, in consequence of the limited capacity of the ponds; and in 1895 the fertilised eggs from other turbot which were obtained, were artificially stripped from the fish.

Mr. Arthur T. Masterman has two papers in the Scottish Report, one on the rate of growth of plaice, and one on hermaphroditism in the cod. The former paper consists largely of comments on Petersen's work and my own; those on the former being complimentary, those on the latter very much the reverse. As he bases his comments largely on theoretical assumptions, I do not think it necessary specially to defend my own work. Mr. Masterman's own contribution to the evidence concerning the growth of plaice consists in the application of Petersen's method of graphic curves to the measurements of plaice taken on the east coast of Scotland by the *Garland*. The curves obtained, especially those of plaice taken in St. Andrew's Bay in 1891, do give successive maxima in the number of individuals at certain sizes, but that these maxima correspond to the broods of successive years seems to me more than doubtful. Thus, according to Masterman, the mid-size of the year old fish in July is 6 in., of the two year old 8½ in., while in November the mid-size of the year old fish is 9½ in., and even in October is 9 in. That is to say, the majority of the year old fish grow 3 in. in length in the three months, July to October, but only

2½ in. in twelve months. Another objection is that, according to Masterman, the plaice of 13 in. mid-size are in July in their fourth year; although it is known that plaice on the east coast of Scotland are at that size, with few exceptions, immature, while three-year-old plaice are nearly all mature. It is true that Masterman only urges that by the method, with a proper series of observations, valuable results *might* be obtained; and if we could explain away the cusp of the curve for July at 6 in., the two cusps at 8½ and 13 in. would represent the plaice in their second and third years, a result which would agree with my own conclusions. In his second paper Mr. Masterman describes two hermaphrodite specimens of the cod, and discusses their condition in relation to hermaphroditism in general. In the course of his remarks he refers to "Nansen's observation of the protandric hermaphrodite condition of *Myxine*," apparently in ignorance of the fact that Nansen's description of that condition was a confirmation of my previous discovery. This is the second time that my discovery of the hermaphroditism of *Myxine* has been attributed in a Report of the Scottish Fishery Board to Nansen. On the former occasion the error was corrected, not by myself, in the columns of *Nature*. If Mr. Masterman had consulted my paper he would have found that the habits of the hag-fish were more definitely known than he seems to suppose.

It should be mentioned that the Report of the United States Commissioner, whose title is given at the head of this article, is merely the report proper, without the appendices, which were issued previously, and which contain detailed accounts of many of the investigations mentioned in the general report. This general report consists of four parts—the Commissioner's own statement, and three divisional reports, one on the division of investigations by Richard Rathbun, one on the division of statistics and methods, and the third on artificial propagation and distribution. Reference to interesting points in the last two divisions has been made, and it remains to mention the character of the investigations carried on by the Commission in the year 1892–93. In 1892 the *Albatross* was employed by the United States Government in investigations of the seal and seal fisheries of the Behring Sea. From August, 1892, till April, 1893, she was under repair at San Francisco, after which, by direction of the President, she joined the fleet which was employed in patrolling the North Pacific and Behring Sea. The naturalists belonging to the ship remained with her, except when she was under repair, and carried on observations concerning the seals, and the fishes of the places visited, as opportunities occurred.

On December 6th, 1892, an agreement was concluded between the

Governments of Great Britain and the United States, which provided for the appointment of a joint commission of two experts, one on behalf of each Government, to report upon the fisheries in the territorial and contiguous waters of the United States and Canada. The reports were to be presented within two years, and the object in view was the recommendation of practical and administrative measures to be adopted by both authorities. The two Commissioners appointed were Mr. Richard Rathbun and Dr. William Wakeham, and their investigations during the time covered by this report were confined to the mackerel fishery.

Various other investigations, such as the survey of oyster beds in Chesapeake Bay and Galveston Bay, the study of the lobster by Professor Herrick, at Wood's Hole, the discovery that the tile-fish had returned to the Continental slope, south of New England, with the return of warm water to that region in consequence of a change in the interaction of the currents, are mentioned, but the full description of them is to be found in special papers.

The Fourth Report of the Danish Biological Station.

By

F. B. Stead, B.A.

THE PLAICE IN DANISH WATERS.—The Fourth Report of the Danish Biological Station consists of a lengthy paper by Dr. C. G. J. Petersen "on the Biology of our Flat-fishes and on the Decrease of our Flat-fish Fisheries," which was awarded a prize by *Det Kongelige danske Videnskabernes Selskab*, and which certainly deserves the careful attention of all who are interested in fishery questions. The first chapter gives a fairly complete account of some of the main features in the life history of the plaice in the Danish seas, together with shorter notes on other flat-fishes; the second and third are occupied by a discussion of the reasons for the deterioration of the fisheries, and of the remedial measures by which this evil may in the future be prevented. The paper is supplemented by five appendices, one of which, on the post-larval stages of flat-fishes, is of particular interest. For the full English translation with which we are provided English naturalists can but express their gratitude to the author.

The first question to which our attention is drawn in this paper is that of the variations in size, which plaice from different localities are found to exhibit.* These differences are seen on comparing the average sizes of plaice which have just arrived at maturity, and also the average sizes of mature (grown-up) plaice (*i.e.*, three years old and over) from different localities. Thus while in the Baltic the average size of mature plaice is about 10 inches, it is 11 inches in the Lesser Belt, and 12–13 inches in the Cattegat. Whether this gradual decrease in the average size of the mature fish, as we pass from the Cattegat to the Baltic, is due to a corresponding gradual change in the conditions favourable to growth, or whether it implies a migration of the larger plaice from the Baltic towards the Cattegat, is not certain, but there are reasons for thinking that the plaice of the Baltic do not enter that sea in any numbers till they are one year old, so that to speak of a race of plaice peculiar to the Baltic would be erroneous.

Further, as we pass from the German Ocean to the Baltic, there is a gradual decrease of the size at which plaice become ripe for the first time. If to these differences others (*e.g.*, in the number of fin rays) be added, the existence of separate races is still unproved. For seeing that the eggs and fry of all the plaice are pelagic, and must in consequence all be mixed together, the appearance of one form of plaice in the Baltic and another in the Cattegat, must be due either to the fact that the eggs of one form cannot live when carried into the territory of the other, or that the differences between the two forms are wholly ontogenetic. Of these two alternatives our author is inclined to accept the second.

Perhaps the most interesting part of Petersen's paper is that in which he describes his method of determining the rate of growth of plaice. By fishing at any given time of year in a number of different places, at different depths, and with nets of various kinds, and measuring all the fish caught, Petersen found that the fish were grouped about certain maxima corresponding to the most common lengths of the fishes born in successive years. These groups he calls the "0 group," consisting of fish less than one year old, the "1 group" between one and two years old, the "2 group" between two and three years old, and the "3 group" consists of fish three years old and over.

Leaving for a moment the question of how far this method of determining the rate of growth of the fish, and the probable age of any particular individual, is a sound one, we may pass on to a brief resumé of the life history of the plaice in Danish seas as traced by Petersen. The spawning season lasts from November to April, with a maximum in January and February. The larvæ, so long as they retain their yolk sac, are 6–7 mm. long. "When the yolk sac is absorbed, and the fish have become unsymmetrical and compressed, with their left eye sitting nearly on the edge of the brow, but while they are still transparent pelagic fish, they are 10 to 12 mm. long." The length at which the metamorphosis is complete, appears to vary from 10 mm. to 13 mm. Petersen was unable to find the young plaice of 12 mm. before the month of May, and concludes that the larvæ hatched in November take six months to pass through their pelagic stage. The same does not hold, however, for the turbot, the brill, the flounder, and the sole, in all of which the spawning season begins later than in the case of the plaice.

---

* Cf. Cunningham. "North Sea Investigations"—this Journal, vol. iv. nos. 1 and 2; especially no. 1, pp. 23–25, and no. 2, pp. 97–108.

Further, the young plaice of 12 mm. in length are always found close in on the shores, and never in water of two fathoms and over. From this fact Petersen draws the conclusion that of the pelagic fry in the sea only those which happen to be near the shore at the time when metamorphosis takes place can survive. It is the physical conditions then, and not the presence of enemies, which causes that enormous destruction of larvæ which undoubtedly takes place.

The young fish belonging to the "0 group," which have all reached the length of 12 mm. by the month of May, grow to a length of 2–4 inches by the following autumn. In the succeeding winter they cannot easily be found on the shores, and it is suggested that they bore down deep into the sand where the seine cannot reach them. By the end of their first year the young fish migrate into deeper water, and this migration probably begins in the winter months. An investigation made at Aalbek in July, 1893, showed that the plaice were larger the deeper the water examined. Summarising the results of this investigation it was seen that besides the "0 group," which were found in water of less than 2 fathoms, there was a "1 group" from 2½–2 inches at 5 fathoms, and a "2 group" from 6¼–10 inches, which began to appear in water of 8 fathoms.

The different groups are not, however, found in all the seas. On the contrary, while as we have already seen, the "0 group" is entirely absent from the Baltic, the plaice in their second and third years are present in considerable numbers. The largest specimens (14 in.) found in the Baltic, probably represent the 3 group, and the size at which the 2 group meets the 3 group, is set down at 8 to 9 inches. On the other hand, fish of 3 years old and over are not found in the Northern Cattegat in any numbers "without much searching"; and it seems clear that owing to persistent over-fishing there has been in recent years a decrease in the size of the plaice caught in the Cattegat. As Petersen remarks in pathetic italics, "*they do not get time in the Cattegat*"—cut off, as it were, by ruthless fishermen before they attain their prime! The fact that the "3 group," which is almost absent from the Cattegat, and but poorly represented in the Baltic, is found in the intervening seas, has suggested the view that an emigration of three-year-old plaice takes place from the Baltic.

Turning now to the question of the accuracy of the method employed for determining the rate of growth of fish, it seems clear that while the existence of the natural groups, each varying about a most common length, correspond to the average size of fish of that age is clearly shown; a reference to Petersen's tables leaves the impression that considerable uncertainty exists as to where one group ends and another begins, and as to the exact position of the most common length for each group. And this is practically admitted, when the remark is made that "besides distinguishing the sexes, we ought also properly . . . . to fish the same number of specimens of each annual series, in order not to efface the boundary lines between them." How can we be sure that this is done?* In cases where fish of all the different ages can be fished "in one draught" the difficulty is no longer present.

It was mentioned above that plaice less than 1 year old were not found in the Baltic. Hensen has, however, shown that the eggs of the plaice are found there; and the absence of the young fish is accounted for by the peculiar hydrographical conditions which obtain in that sea. For experiments made by Petersen, in Copenhagen, on living plaice eggs, proved that the highest specific gravity at which all the eggs sank was 1·0120   10° C., corresponding to a salinity of 1·44 per cent.; and Hensen's investigations prove that "*almost every month* there occurs such a low salinity that the eggs *must sink to the bottom*." If, as is probable, the eggs, on sinking to the bottom, are killed, the absence of the young fish is clearly accounted for.

The same does not, however, hold for the turbot, the brill, or the flounder. The fry of these fish are sometimes met with in multitudes on the shores of the Baltic, while in the Cattegat young flounders are found in company with young plaice. With regard to the turbot and the brill the explanation given is that the pelagic fry of these fish are more hardy than those of the plaice, and so can live in water of a lower salinity.

With regard to the *food* of plaice of different ages a short summary of the main facts is given by our author. Thus, during the pelagic stages the food consists chiefly of copepods; and even when the fish have grown to 1¼ to 1¾ inches, "*Copepoda, Cladocera, Ostracoda*, and *the larvæ of bivalves*" may form their food.

At a length of 2 in. to 3 in., however, the diet has changed, and now consists of *Idothea, Gammaridæ*, smaller *Annelida*, and the *fry of bivalves*." When the fish have grown to a length of 3 to 5 in., "they

---

[* Cf. for a more detailed criticism of Petersen's results CUNNINGHAM's paper in this number of the Journal pp. 136–138.]

take in the main the same sort of food as the older plaice," and after the end of their first year there is no change in the character of the food of the plaice.

We may now pass on to our author's discussion of the economic question: how may the plaice fishery be prevented from further deterioration? We may say at once that Petersen is in favour of the imposition of a size limit, but for reasons somewhat different from these commonly given in support of this proposition. He points out that the object to be kept in view is to make the fishery yield as large a profit as possible. It is necessary, therefore, to allow the fish to grow to such a size, that the largest possible weight of fish involving the highest selling price can be obtained.

Now, a plaice of 10 in. weighs less than ½ lb., and one of 14 in. more than twice as much: it follows that, unless in the time that it takes 10 in. plaice to grow to 14 in., the mortality is such as to reduce the population of these plaice to less than half its original number, the total weight of the plaice at 14 in. will be greater than at 10 in. It is not likely that the death-rate is as high as this, because the plaice does in fact grow to a much larger size than 14 in.; further, it would seem that disease is almost unknown among these fish: and their enemies are apparently few. Hence, by allowing the 10 in. plaice to grow to a larger size before capturing them a greater profit will be obtained. There will of course be a limit of size beyond which it will not be profitable to allow the fish to grow, and this limit will depend on the death-rate at each size.

Our author contrasts his view, which he calls the "growth theory," with the "propagation theory" of other writers. Those who hold this latter view insist on the necessity of increasing the *number of individuals*, and, in recommending a size limit, are happy if they can secure that the fish shall be allowed a chance of spawning. Petersen, on the other hand, thinks it of more importance to allow the fish to grow to the size at which they will yield a maximum profit, and holds that ample provision is made in nature for keeping up the numbers. As his point of view is an important one, and as it is stated with great clearness, I do not hesitate to quote him on this point *in extenso.* "It has always been hard for me to believe that there should be any want of eggs of plaice in our seas, partly because Hensen's excellent investigations have shown what immense quantities there are of them, partly because I myself see our seas filled with such eggs. Nor have I ever been able to believe in any want of young plaice. . . . Nay, everything seems to me to indicate that it is not in the *beginning*, but *in the middle and end of the life of the plaice* that we must look for the injury; for it is here that man interferes as a troublesome factor."* And again, "If we fish the plaice while they are small, we do not get so great a profit from them as we might and ought to have. *In this only, so far as I can see, the 'destruction' consists.*"†

It is of interest to notice that the view here set forth appears also in the discussion on the desirability of a close time for crabs and lobsters.‡ And if it is assumed for any species—(1) that the provision made in nature for keeping up the numbers of individuals is more than sufficient, and (2) that owing to *natural* influences, the number of surviving *grown-up* individuals is fixed and relatively small, then it will follow that the continual destruction caused by man must of necessity lead to a decrease in the number of large individuals, and that this decrease cannot be met either by artificial propagation, or by the imposition of a *small* size limit. These two assumptions appear to me to underlie the view which our author puts forward as the "growth theory"; and the first of them implies that there is, under natural conditions, an excessive wasteful production of young fish.

Our author further points out that, in respect of the plaice, both theories will lead to a similar practical conclusion—the imposition of a size limit; though the effective size limit, from the point of view of the "growth theory," will be higher than that which is required by the "propagation theory." This, however, does not hold good in all cases. The eel-fishery, for instance, consists wholly in the capture of eels which have never spawned. "The propagation theory would be obliged to require a size limit of at least 20 inches, in order to protect the stock of eels satisfactorily; *but then the males could not be caught at all.*"§ The growth theory, on the other hand, would be content with a lower limit.

It will be seen that the questions raised by the discussion of these different theories are of great practical importance. They are among the scientific problems which call for settlement, before sure guidance can be given to the legislator.

---

* *Loc. cit.* pp. 61, 62. (*In all quotations the italics are Petersen's.*)

† *Loc. cit.* p. 57.

‡ *Cf.* p. 186, this number of Journal, answers of fisherman to cross-examination by Messrs. Pannett and Mally.

§ *Loc. cit.* p. 82, footnote.

Director's Report.

THE investigations into matters connected with economic fishery questions have been carried on with considerable success, during the summer and autumn months. Mr. J. T. Cunningham has visited various fishing centres on the East Coast, and has been able to supplement the observations made by Mr. Holt and himself at Grimsby, in some important respects, by thus extending the field of investigation. As will appear from the full report published by Mr. Cunningham in this number of the Journal, he has, amongst other things, shown that two distinct races of plaice occur in the North Sea. It had already been ascertained that the plaice of the English Channel formed a smaller race than those generally landed at Grimsby from the North Sea. The evidence now obtained from Lowestoft proves that the plaice brought to that port from the Dutch coast, south of the Texel, are no larger than those of the English Channel, so that the high size limit proposed to be applied to the plaice landed at Grimsby would be quite inapplicable to those landed at Lowestoft.

Mr. F. B. Stead has commenced an investigation of the fish which inhabit the bays on the South Coast of Devon, at present closed to trawlers. The results of this investigation promise to be of great interest. From the facts at present ascertained, it appears that during October and December, the only fish which are taken in these bays in sufficient numbers to be of importance, from a practical point of view, are plaice and dabs. Of these two species, the plaice only are valuable, and the large number of competing dabs must probably be regarded as a positive hindrance to their well-being. Any controversy that may be raised, therefore, as to the advisability or otherwise of keeping these bays closed to trawlers, should be solely occupied with the consideration of the question whether such closure is necessary or desirable for the protection of plaice. It has further been shown that the bays differ markedly from one another in respect of the sizes of the fish they contain, for whilst half the plaice in Start Bay were found to be over 12½ inches in length, in Teignmouth Bay half the plaice captured were under 10½ inches.

I have given, in another part of the present number of the Journal, a brief account of the investigation which is being carried on into the fauna and flora of the outlying grounds between the Eddystone and Start Point. It is proposed, during the next six months, to dredge over the same grounds again, in order to confirm the results already arrived at, and to fill in the many gaps which at present exist in the rough charts that have been made.

The naturalists who have occupied tables at the Laboratory, since the publication of the list in my last Report, are:—

E. T. Browne, B.A., August 19th to September 30th *(Medusæ)*.
G. Brebner, September 5th *(Marine Algæ)*.
S. D. Scott, B.A., September 16th to October 5th *(General Zoology)*.
A. H. Church, B.A., December 17th to December 25th *(Marine Algæ)*.
E. H. Chapman, December 28th to January 20th *(General Zoology)*.
T. H. Taylor, M.A., January 6th to 10th *(Polyzoa)*.

Of the gentlemen whose names appeared in the previous list, Dr. Bethe remained until the middle of October, and Messrs. Riches and Bidder until December, so that the number of workers at the Laboratory during the later months of the year has been somewhat larger than usual.

It will be noticed that two naturalists have been engaged in the study of marine algæ. It is some time since botanists have taken advantage of the facilities afforded at the Laboratory for this kind of work, but it is hoped that for the future this want of support may not be continued. If those interested in marine botany could obtain the necessary funds for the purpose, it would be an excellent thing to have a botanist permanently stationed at Plymouth.

The following papers, which have recently been published elsewhere than in the Journal of the Association, contain the results of investigations carried on at the Laboratory:—

Barthels, P.—"Notiz über die Excretion der Holothurien," *Zool. Anzeiger*, No. 492, 1895.

Bidder, George.—"The Collar-cells of Heterocoela," *Quart. Journ. Micr. Sci.* xxxviii. p. 9.

Browne, E. T.—"On the Variation of Haliclystus octoradiatus," *Quart. Journ. Micr. Sci.* xxxviii. p. 1.

Garstang, W.—"Budding in Tunicata," *Science Progress*, iii. Mar., 1895.

Garstang, W.—"Outlines of a new Classification of the Tunicata, British Association, Ipswich, 1895.

Hickson, S. J.—"The Anatomy of Alcyonium digitatum," *Quart. Journ. Micr. Sci.* xxxvii. p. 343.

MacBride, E. W.—"The Development of Asterina gibbosa" (*in part*). *Quart. Journ. Micr. Sci.* xxxviii. p. 339.

Nutting, C. C.—"Notes on the Reproduction of Plumularian Hydroids," *Amer. Naturalist*, Nov. 1895, p. 966.

Arrangements have been made by which Mr. Garstang will conduct courses of study in Marine Biology, at the Laboratory, during the Easter Vacation. A special room will be fitted up for the accommodation of students joining this class, and it is hoped that a sufficient number will take advantage of the arrangement, to encourage the formation of such classes in the future. Mr. A. H. Church, of Jesus College, Oxford, is also prepared to conduct a similar class in marine botany.

Before closing this report, I should like to take the opportunity of drawing attention to some facts regarding the general position of the Association, and its work at the present time. As any further development of our activity depends so largely upon questions of finance, it will be well if these are considered first, and in doing this it is necessary to distinguish between the maintenance of the Plymouth Laboratory, and the work carried on there, and the expenses of the investigations into the North Sea Fisheries, which have been so successfully prosecuted on the east coast. The latter have been supported almost entirely by special donations, given from time to time by Mr. J. P. Thomasson, and by the Drapers' and Fishmongers' Companies, and although there is no immediate prospect of funds being forthcoming for their continuation, it is to be hoped that they may not be allowed to lapse for that reason.

Leaving these special investigations out of consideration, the annual income of the Association from all sources, amounts to £1,950, and the estimated expenditure for the general conduct of business, and the maintenance of the Plymouth Laboratory on its present footing, is £1,800, which leaves a balance of £150.

The want at Plymouth, which must be put before all others, is that of a suitable boat. Experience goes more and more to show that the amount of energy wasted, and the limitation put upon our investigations through this want, is exceedingly great. I do not hesitate to say that the effective work of the Association could be increased by, at least, fifty per cent., if a suitable small steamer were in our possession. Instead of confining our collecting to within five or six miles of Plymouth Sound, the whole western half of the English Channel, including the Channel Islands, would become our field of operations; whilst the fishery investigations, which we are attempting, could be done more completely, and with far less expenditure of time and serious inconvenience, and others, which are now quite beyond our power, could be undertaken by the present staff. Our income would be sufficient to maintain a boat large enough for our purpose, if only the funds were available to procure her.

When this question has once been satisfactorily settled, we may, I believe, consider that the Association possesses a well-equipped laboratory, capable of turning out a large amount of valuable scientific and economic work, without any considerable increase of the income at present at our command. It must not be forgotten, however, that the above estimate only allows for one naturalist on the staff of the Association, who can devote any considerable proportion of his time to carrying on research. Further development must then be sought for in the direction of obtaining funds for the appointment of additional naturalists on the staff, for the resources of the Laboratory will be sufficient to keep several investigators constantly employed, without much additional expense beyond their salaries.

Efforts should also be made in all possible directions to induce public bodies to offer scholarships for biological research, which might be held at Plymouth. A number of scholarships are already given to enable the holders to prosecute technical researches in Chemistry and Physics, and if biologists take the matter up, there seems no reason why some of these should not be obtained for fishery investigations. With regard to scholarships for purely scientific work, it is remarkable that whilst the facilities offered to able men, to pursue scientific study up to the examination standard, are by no means limited, opportunities for carrying their work to a legitimate conclusion appear to be granted to but few. Year after year numbers of men turn aside directly they reach the point where their real scientific training may be said to commence. These are the men, whose services in the interests of the Association, or, which is saying the same thing, in the interests of Biology in this country, we should endeavour to retain.

E. J. Allen.

January, 1896.

POSTSCRIPT.

Since the above report was in the press an opportunity of securing a small steam fishing yacht, upon advantageous terms, has presented itself, and as the vessel appeared to be exactly suited to the work of the Association, the Council decided that it would be advisable to purchase without delay. The yacht, the *Busy Bee*, of Fowey, is now in our possession, and it is hoped that the confidence of the Council that the supporters of the Association, by subscribing the necessary funds, will recognise the wisdom of the course they have pursued, may not prove to be misplaced.

I am glad to announce that Mr. J. P. Thomasson has already been kind enough to make a donation of £100 towards the purchase money. A sum of £600 is required, and subscriptions may be sent either to the Hon. Treasurer, or to myself.

E. J. A.

February 13th, 1896.

PUBLICATIONS OF THE ASSOCIATION.

RECENTLY PUBLISHED. *Royal* 8*vo*, 109 *pp*.

AN

EXAMINATION OF THE PRESENT STATE
OF THE
GRIMSBY TRAWL FISHERY,
WITH ESPECIAL REFERENCE TO
THE DESTRUCTION OF IMMATURE FISH.

BY

ERNEST W. L. HOLT,

Late Naturalist on the Staff of the Marine Biological Association.

PRICE ONE SHILLING.

From Messrs. Dulau & Co., 37, Soho Square, London, W.
Or from The Director, The Laboratory, Plymouth.

PUBLICATIONS OF THE ASSOCIATION.

Cloth 4to, 150 pp., 18 plates, (12 coloured).

A TREATISE ON THE COMMON SOLE.

BY

J. T. CUNNINGHAM, M.A.,

Late Fellow of University College, Oxford; Naturalist to the Association.

Price to Members,* 20*s.*; to Non-Members, 25*s.*
From the DIRECTOR, The Laboratory, Plymouth, and through all Booksellers.

JOURNAL OF THE MARINE BIOLOGICAL ASSOCIATION.

OLD SERIES.

No. 1, AUGUST, 1887 (only a few copies left, reserved for Libraries).
No. 2, AUGUST, 1888. Price 1*s.*

NEW SERIES.—VOLUME I.

1889–90.

Royal 8vo, xx. and 472 pp., 28 plates.

NEW SERIES.—VOLUME II.

1891–92.

Royal 8vo, x. and 404 pp., 14 plates, 12 woodcuts, and 10 charts.

Price, in neat cloth binding, 15*s.* 6*d.*; to Members,* 12*s.*
Separate numbers, in wrappers, 3*s.* 6*d.*; to Members,* 2*s.* 8*d.*

NEW SERIES.—VOLUME III. PARTS 1, 2, 3, 4, and SPECIAL NUMBER.

May, 1893; March, 1894; October, 1894; February, 1895; June, 1895.
Separate numbers, in wrappers, 3*s.* 6*d.*; to Members,* 2*s.* 8*d.*

* Members who desire to obtain the publications at a reduced rate must apply to the Director, and not to the London Agents.

From the DIRECTOR, The Laboratory, Plymouth.
And from the London Agents: Messrs. DULAU & Co., 37, Soho Square, W.

OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Professor LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence, the Association has erected at Plymouth a thoroughly efficient Laboratory, where naturalists may study the history of marine animals and plants in general, and where, in particular, researches on food fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent, for the use of a working table in the Laboratory, and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter, the payment of servants and fishermen, the hire and maintenance of fishing boats, and the salary of the Resident Director and Staff. At the commencement of this number will be found the names of the gentlemen on the staff. In no case does any one salary exceed £250.

The Association has received some £25,000, of which £11,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £7,000.

The ASSOCIATION IS AT PRESENT UNABLE TO AFFORD THE PURCHASE AND MAINTENANCE OF A SEA-GOING STEAM VESSEL, by means of which fishery investigations can be extended to other parts of the coast than the immediate neighbourhood of Plymouth. Funds are urgently needed in order that this section of the work may be carried out with efficiency, The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS OF NEW SERIES, Vol. IV., No. 2.

PAGE

1. The Reproductive Maturity of the Common Eel. By J. T. Cunningham, M.A. 87
2. Preliminary Note on Trawling Experiments in Certain Bays on the South Coast of Devon. By F. B. Stead, B.A. . . . 90
3. North Sea Investigations (Continued). By J. T. Cunningham, M.A. 97
4. A Carcinus with a Right-handed Walking-leg on the Left side of the Abdomen. Preliminary Note by Albrecht Bethe . . 144
5. Notes on Plymouth Hydroids. By C. C. Nutting . . . 146
6. A List of the Parasitic Copepoda of Fish obtained at Plymouth. By P. W. Bassett-Smith, Surgeon, R.N. 155
7. Faunistic Notes. By E. J. Allen, B.Sc., W. Garstang, M.A., E. T. Browne, B.A., and T. V. Hodgson 164
8. Algological Notes. By George Brebner 179
9. The Protection of Crabs and Lobsters. By E. J. Allen, B.Sc. . 182
10. Report on the Sponge Fishery of Florida, and the Artificial Culture of Sponges. By E. J. Allen, B.Sc. . . . 188
11. Note on Projects for the Improvement of Sponge Fisheries. By George Bidder 195
12. Recent Reports of Fishery Authorities. By J. T. Cunningham, M.A., and F. B. Stead, B.A. 203

Director's Report 219

NOTICE.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for statements published in this Journal, excepting when those statements are contained in an official report of the Council.

TERMS OF MEMBERSHIP.

		£	s.	d.
Annual Members	per annum.	1	1	0
Life Members	Composition Fee.	15	15	0
Founders		100	0	0
Governors		500	0	0

Members of the Association have the following rights and privileges; they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

All correspondence should be addressed to the Director, The Laboratory, Plymouth.

New Series.—Vol. IV., No. 3—issued August, 1896.] [Price 3s. 6d.

SEP 17 1896

11,974

Journal

OF THE

MARINE BIOLOGICAL ASSOCIATION

OF

THE UNITED KINGDOM.

THE PLYMOUTH LABORATORY.

A

PLYMOUTH:
PRINTED FOR THE MARINE BIOLOGICAL ASSOCIATION BY W. BRENDON & SON,
AND
PUBLISHED BY THE ASSOCIATION AT ITS OFFICES ON THE CITADEL HILL.
SENT FREE BY POST TO ALL MEMBERS OF THE MARINE BIOLOGICAL ASSOCIATION:
ANNUAL SUBSCRIPTION FOR MEMBERSHIP, ONE GUINEA.
Agents in London:—Messrs. DULAU & Co., 37, Soho Square, W.

PATRON.

H.R.H. THE PRINCE OF WALES, K.G., F.R.S.

OFFICERS AND COUNCIL.

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G., K.T., F.R.S.
The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Revelstoke.
The Right Hon. Lord Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Sir John Lubbock, Bart., M.P., F.R.S.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Sir Wm. Flower, K.C.B., F.R.S.
A. C. L. Günther, Esq., F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson.
Rear-Admiral Wharton, C.B., F.R.S.

COUNCIL.

Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffrey Bell, F.Z.S.
G. C. Bourne, Esq., F.L.S.
Sir John Evans, K.C.B., Treas. R.S.
G. Herbert Fowler, Esq.
S. F. Harmer, Esq.
Prof. W. A. Herdman, F.R.S.
Prof. S. J. Hickson, F.R.S.
J. J. Lister, Esq.
John Murray, Esq., F.R.S.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
D. H. Scott, Esq., F.R.S.
Prof. Charles Stewart, F.R.S.
Prof. W. F. R. Weldon, F.R.S.

Governors.

Robert Bayly, Esq.
J. P. Thomasson, Esq.
The Prime Warden of the Fishmongers' Company.
E. L. Beckwith, Esq. (Fishmongers' Company).
Prof. Burdon Sanderson, F.R.S. (Oxford University).
Prof. Michael Foster, F.R.S. (Cambridge University).
Sir William Flower, K.C.B., F.R.S. (British Association).

Hon. Treasurer.

E. L. Beckwith, Esq., The Knoll, Eastbourne.

Hon. Secretary.

E. J. Allen, Esq., The Laboratory, Citadel Hill, Plymouth.

PERMANENT STAFF.

Director—E. J. Allen, Esq., B.Sc.

Naturalists.

J. T. Cunningham, Esq., M.A.
F. B. Stead, Esq., B.A.

Assistant to the Director—T. V. Hodgson, Esq.

SEP 17 1896

Contributions to Marine Bionomics.

By

Walter Garstang, M.A.,
Fellow and Lecturer of Lincoln College, Oxford.

I. The Habits and Respiratory Mechanism of Corystes cassivelaunus.

Corystes cassivelaunus is a crab of unusually narrow and elongated form, which has received the popular name of "masked crab" from the grotesque resemblance which its sculptured carapace bears to a human face. It is common round all the coasts of the British Isles, and, although normally an inhabitant of the deeper water, is occasionally found at home in sandy pools on the sea shore, and is frequently cast up in hundreds on sandy shores after heavy gales.

I. SYSTEMATIC POSITION.

The systematic position of the Corystoidea has long been a disputed point among carcinologists. Henri M. Edwards (1834) placed the Corystoid crabs near the Dorippidæ among the Oxystomata, and regarded them as connecting links between the Cancroidea (*viâ* the Calappidæ) on the one hand, and the Anomoura on the other.

De Haan (1849) removed the family from the group Oxystomata altogether, and placed it with the Cyclometopa and Catometopa of M. Edwards, in a separate sub-division of the Brachyura, the Brachygnatha.

Dana (1852) made of the Corystoidea an independent and primary tribe of the Brachyura, distinct from the Cancroidea and Leucosoidea alike.

Alphonse Milne-Edwards (1860) reverted to the older view, and placed the Corystidæ near the Calappoid Oxystomata. Heller also (1863) placed the Corystidæ among the Oxystomata.

Finally, Claus (1880) definitely placed the Corystidæ in the Cyclometopa. In this he has been followed by Miers (1886) and Stebbing (1893).

It cannot be said, however, that the real position and affinities of the Corystidæ are yet established. The reason for this uncertainty is probably due to the fact that, as will appear further on, the structure of these animals is remarkably modified in relation to sand-burrowing habits. Some of these adaptive modifications of structure, which reappear in certain other groups of Crustacea, have undoubtedly impressed the minds of certain writers with ideas of homology and genetic relationship between the Corystidæ and groups having no real affinity with that family. The case affords a new illustration of the inadequacy of the purely morphographic method, when unchecked by considerations of functional adaptation, for the solution of problems of relationship and genetic classification.

II. Structural Peculiarities.

The structure of *Corystes cassivelaunus* is noteworthy on account of the following features. The second antennæ are greatly elongated—as long as, or longer than, the body—and are fringed along their entire length by two rows of hairs, one of which runs along the ventral, while the other runs along the dorsal border of the antenna. The hairs of each row curve inwards towards those of the corresponding row on the second antenna of the opposite side. The second antennæ shew a marked tendency to approximate to one another longitudinally; the opposing rows of hairs then interlock, with the resulting formation of a median tube, the lateral walls of which are formed by the jointed flagella of the antennæ, while the dorsal and ventral walls are fenestrated along their whole extent by the interspaces between the interlocking hairs. The organ formed by the apposition of the second antennæ I shall term the "antennal tube."

The long axes of the three stout basal joints of the second antenna are disposed at right angles to one another, and bring about a characteristic double bend in the basal part of the antenna. The double row of hairs found on the flagellum of the antenna is continued backwards along these three basal joints. The hairs on the most distal of the three joints interlock with those of the corresponding joint of the opposite antenna; the hairs on the anterior face of the deflected middle joints bend inwards towards the median line along the sides of the rostrum, and together with a median triangular tuft of hairs springing from the rostrum itself, form the hairy roof of the proximal part of the antennal tube.

The antennal tube opens posteriorly into a rectangular chamber in front of the mouth. This "prostomial chamber," as it may be termed, is roofed by the rostrum in front, the antennal and epistomial sternites in the middle, and the prelabial plate behind. It is flanked by the two basal joints of the second antennæ in front, and by a forward process of the pterygostomial region of the carapace behind. Its floor is imperfect, and is formed by the anterior part of the third maxillipeds behind, and by a quadrangular sieve in front, furnished by the hairs springing from the two basal joints of the second antennæ, the anterior pterygostomial processes, and a special anterior process of the fourth joint of the external maxillipeds. The hairs from all these parts are directed inwards towards the centre of the quadrangular space outlined by the boundaries of the prostomial chamber, and constitute a complete sieve-like floor to the chamber in question. On each side this prostomial chamber leads by a wide aperture into the branchial cavity.

The participation of the epistome together with the prelabial space in the formation of a prostomial chamber is one of the features which strongly distinguishes the Corystoid crabs from typical Cyclometopa, Catometopa, and Oxyrhyncha. The arrangements of these parts approximates in some respects to that found in the Oxystomata, where the buccal frame or the peristome is prolonged anteriorly as a definite prostomial chamber to the very tip of the snout. This chamber in the Oxystomata, however, is completely closed in by the third maxillipeds, and is very narrow anteriorly; in the Corystoidea, on the other hand, it is broad in front, and is imperfectly closed by the third maxillipeds.

III. PREVIOUS OBSERVATIONS ON HABITS.

In Bell's "British Stalk-Eyed Crustacea" (1853) a brief reference is made to the sand-burrowing habits of *Corystes cassivelaunus.* Couch had already described the crab as "burrowing in the sand, leaving the extremities of its antennæ alone projecting above the surface." The actual process of burrowing appears not to have been observed at the time when Bell wrote, for he quotes Couch's suggestion that the elongated antennæ possibly "assist in the process of excavation." This theory of the function of the antennæ was subsequently rejected by Gosse (1865), as a result of his own observations on the habits of the crab, and again by Hunt (1885), who correctly states that the crab descends into the sand backwards with the greatest agility, "thus leaving the antennæ no opportunity of assisting in the operation."

The first writers to offer anything approaching a real explanation of the use of the antennæ were the veteran naturalist of Cumbrae, Mr. David Robertson, and Mr. P. H. Gosse. It is difficult to say, and would indeed be ungenerous to enquire, which of these two naturalists has the priority in the matter. Gosse, in 1855, described the outer antennæ of *Corystes* as "together forming a tube" (*Manual of Marine*

Zoology, I., p. 158), but he did not apparently publish his observations in full until 1865.

In the meantime Mr. David Robertson communicated to the Philosophical Society of Glasgow, on March 13th, 1861, an interesting note on the function of these antennæ. He described the burrowing habits of the crab, and shewed that, under these circumstances, the antennal tube preserved "a free passage for the purpose of enabling the animal to carry on the process of its aqueous respiration." Mr. Robertson believed, with Gosse, that the current through the tube was exhalent in character. In another paper he stated that "he had seen the ova cast up through the opening [of the antennal tube]—the inference being that the animal had placed it by means of its claws within the influence of the current." (*Proc. Nat. Hist. Soc., Glasgow*, vol. i. p. 1.)

Gosse (1865) similarly observed that each antenna, from the form and arrangement of its bristles, constituted a "semi-tube, so that when the pair was brought face to face the tube was complete." He also carefully watched a living specimen, as it was sitting upright on the top of the sand, close to the side of a glass aquarium, and observed that the antennal tube formed a channel for a definite current of water. To quote his own words: "I immediately saw that a strong current of water was continuously pouring up from the points of the approximated antennæ. Tracing this to its origin, it became evident that it was produced by the rapid vibration of the foot-jaws, drawing in the surrounding water, and pouring it off upwards between the united antennæ, as through a long tube. . . ." "I think, then, that we may, with an approach to certainty, conclude that the long antennæ are intended to keep a passage open through the sand, from the bottom of the burrow to the superincumbent water, rendered effete by having bathed the gills; and it is one of those exquisite contrivances and appropriations of structure to habit which are so constantly exciting our admiration . . . [and] are ever rewarding the research of the patient observer."

We shall see below that while Gosse's conduit-theory of the function of the antennæ is perfectly correct, his inferences as to the function of the antennal conduit are true only to a limited extent. Gosse assumed that the habits of the crab when beneath the sand were similar to its habits when above the sand, and confined his observations to the crab in the latter condition. Experiment shews, however, that there may be a marked difference in the working of certain organs under the different conditions.

A third theory as to the function of the antennæ in *Corystes cassivelaunus* is due to Mr. A. R. Hunt (1885). He says, "I incline to think that the function of the antennæ is to maintain a communication between the buried crab and the water above, as without some such connexion there would be a risk of the animals being occasionally buried to a dangerous depth by the accumulation of sand above them. Mr. W. Thompson's statement that the antennæ in very small specimens are much longer in proportion to the carapace than in the adult harmonizes well with this hypothesis, as to ensure safety the young would have to burrow to a greater depth compared with the adults than would be proportionate to their size." Mr. Hunt was not aware of Gosse's view when he framed the above theory; but, subsequently, in a footnote to his paper, he referred to Gosse's theory as identical with his own. The two are, however, essentially distinct, if I correctly understand Mr. Hunt's language. According to Gosse's view, the function of the antennæ is to produce a tube subservient to respiration; according to Mr. Hunt's, the function of the elongated antennæ is essentially sensory, viz., to enable the buried crab to determine the depth to which it burrows. The "danger" to which Mr. Hunt refers is clearly not the danger of suffocation, but the danger of dislodgment from the sand by wave-currents. The arenicolous habits of *Corystes* are adduced by Mr. Hunt to illustrate one of the various methods adopted by marine animals for resisting wave currents—a view which, in the case of *Corystes,* I am unable to accept, partly on account of the normally deep water habitat of the crab, and partly on account of evidence given below which tends to shew that the burrowing habits of *Corystes* are adopted primarily for concealment.

IV. New Observations and Experiments.

(a) Burrowing Habits. A number of living *Corystes cassivelaunus* were placed in a series of vessels containing sand of different degrees of coarseness, and it was soon noticeable that these crabs readily burrow in fine sand, but find great difficulty in penetrating very coarse sand or gravel composed of small pebbles. Moreover, a crab that has obstinately declined for several hours to burrow in coarse, gravelly sand, will immediately bury itself, if placed in an aquarium of fine sand. In all cases the process of burrowing is effected exclusively by means of the thoracic legs. The crab sits upright on the surface of the sand; the elongated, talon-like claws of the four hindmost pairs of legs dig deeply into the sand; the body of the crab is thus forcibly pulled downwards by the grip of the legs, and the displaced sand is forced upwards on the ventral side of the body by the successive diggings and scoopings of the legs; the slender chelate arms of the first thoracic pair assist in the process of excavation by thrusting outwards the sand which accumulates round the buccal region of the descending crab. This action at the same time, no doubt, loosens the sand in the immediate neighbourhood, and

renders easier and quicker the descent of the crab into its sandy burrow. Briefly stated, in fact, the four hindmost pairs of legs are all engaged in pulling the crab downwards, while the first or chelate pair is engaged in pushing away the more superficial sand in the neighbourhood of the crab's maxillipeds. The two actions combine to drive the crab downwards and obliquely backwards. The main object of this latter motion appears to be the prevention of any forcible intrusion of sand into the buccal apparatus.

When the carapace of the crab has completely disappeared beneath the surface of the sand, the antennæ are frequently seen to be rubbed obliquely against one another for two or three strokes, whereby the hairs on the antennæ are cleansed from adhering particles. This very characteristic action of the antennæ was noticed long ago by Couch, and correctly recognised by him as a process of cleansing (*vide* Bell, p. 161). After this cleansing process, however, the crab proceeds still further in its act of burrowing, and descends deeper and deeper until nothing is visible above the sand but the most distal portion of the antennal tube.

Resting passively in its bed of sand, *Corystes cassivelaunus* spends the daytime thus concealed from all observation. In aquaria an individual will occasionally emerge and remain on the surface of the sand for some time, but this can usually be attributed to the restlessness resulting from strange conditions. I am inclined to think that if the water and sand provided be of a perfectly suitable character, *Corystes* will remain imbedded throughout the day. (cf. Robertson, l. c. *supra*).

I have noticed, however, that individuals which were inactive and concealed beneath the sand during the day, shewed a marked tendency to activity at night. I have observed on several occasions that my aquarium, containing some half-dozen of these crabs, was the scene of distinct excitement and activity late at night; the crabs had emerged from the sand, and were restlessly hobbling about on the surface, as though in search of food. Although I cannot make a final statement upon the point, all my experiences incline me to the view that *Corystes cassivelaunus* is a nocturnal animal; it conceals itself in the sand by day as a protection from sight-feeding fishes, but emerges at night for food and recreation. If these habits were absolutely constant, we should expect to find the eyes of *Corystes* undergoing retrogressive changes, as, for example, in the case of *Pinnotheres*. Such is not the case, however, for the eyes are capable of forming distinct images, as well as, no doubt, of distinguishing light from darkness.

(*b*) *Respiratory Currents.* We have seen that Gosse observed a current of water setting upwards from the buccal region of the crab through the antennal tube, and carrying upwards the water which had previously bathed the gills. This current was caused, according to Gosse, by the "vigorous vibration of the foot-jaws." The crab observed by Gosse was sitting on the top of the sand—not beneath it.

If some sea-water be coloured by the addition of a little Chinese ink, or finely powdered carmine (the former is the better material), and if a few drops of the coloured water be added to the water in the neighbourhood of the antennal tube of a buried crab, it will invariably be found that the current which sets through the antennal tube is from above downwards, and not *vice versa*. The same current may often, and indeed generally, be shewn to exist, even when the crab is not imbedded in the sand.

It will then be noticed that the coloured water is sucked between the hairs of the antennal tube, and passes downwards and backwards to the prostomial chamber. Here, in front of the labium, the current divides into two streams, one right and one left, which pass outwards and backwards into the right and left branchial chambers respectively. Finally, the coloured stream emerges from the branchial chamber beneath the edge of the branchiostegite, not at any one point, situated either anteriorly or posteriorly, but along its whole extent, and especially between the bases of the legs.

The direction of this current through the branchial chamber is the reverse of that which has hitherto been recognised in all other Decapod Crustacea. In these (*e.g.*, *Maia*, *Cancer*, *Carcinus*, *Astacus*) the current which bathes the gills is known to enter this chamber beneath the branchiostegite, and to emerge in front by the lateral aperture at the side of the mouth. The normal peribranchial current in Decapod Crustacea is from behind forwards; I shall, therefore, term the current of the buried *Corystes* a "reversed current," and shall speak of the whole phenomenon as a "reversal" of the normal current.

Although *Corystes cassivelaunus* constantly exhibits this reversed current when imbedded in the sand, yet it is occasionally possible to observe the normal current in the same specimen when the animal is not buried. The coloured water is then rejected when added near the antennal tube; but if deposited near the bases of the legs, is sucked inwards, and eventually emerges from the branchial cavity into the prostomial chamber, and thence passes either directly to the exterior or forwards by way of the antennal tube. When the normal current is at work it frequently happens that the exopoditic palps of the maxillipeds begin to vibrate. The action of these palps still further intensifies the force of the exhalent currents, and at the same time disperses the streams of water laterally, *i.e.*, the water, instead of passing to the exterior anteriorly in an even stream, is partially diverted to the sides of the crab's body, and is scattered outwards and laterally by the vigorous lashings of the exopoditic palps.

Gosse's observations on the respiratory currents of *Corystes cassivelaunus* are thus seen to be incomplete rather than inaccurate. A current *may* be directed outwards through the antennal tube, and the effete water from the branchial chamber *may* be carried away by that channel; but such a direction of the current in *Corystes cassivelaunus* is not constant, as Gosse believed, or even usual. Moreover, when the crab is imbedded in sand, the current is always reversed, except for a few seconds now and then, when the crab desires to eject distasteful particles which have entered the prostomial chamber with the respiratory current. Under such circumstances the reversed inhalent current through the antennal tube is temporarily replaced by a forcible exhalent current. But as soon as the desired ejection has been effected, the reversed current is again set up. This voluntary inhibition of the reversed current can be easily demonstrated by the addition of carmine to the water setting through the antennæ. Oddly enough, a weak solution of Chinese ink is less distasteful to *Corystes* than a mixture of powdered carmine and sea-water.

(c) Cause of the Currents. The direction of the respiratory currents is exclusively due to the movements of the scaphognathite, the valve-like and highly muscular appendage of the second maxilla, which is known to produce the regular respiratory currents of other Decapoda. H. Milne-Edwards first demonstrated the important *rôle* played by the scaphognathite in Decapod Crustacea; and he maintained that the direction of the respiratory current was absolutely constant, *i.e.*, from behind forwards in all Decapods (1839, p. 136). De Haan (1850, p. 117) has indeed suggested that the current to the branchiæ passes from before backwards; but his remarks on this subject are obviously the result of mere inference, and are not determined by actual experiment. He states, for example, that in *Portunus* the inhalent current sets inwards not only through the aperture between the base of the cheliped and the edge of the branchiostegite, but also through the anterior aperture at the side of the mouth. Experiments on *Portunus* have shewn me that this is quite devoid of foundation; the water certainly enters—in part—through the former of these apertures, but the aperture at the side of the mouth is invariably exhalent in function.

In the case of *Corystes* I observed the action of the scaphognathite by removing the three maxillipeds and the edge of the pterygostomial fold of a living specimen. The scaphognathite was completely exposed by this preparation, and its movements were readily followed.

When the normal current—from behind forwards—was at work, the propulsion of the water could be seen to be effected by a sharp, prompt blow dealt by the posterior lobe of the scaphognathite, which was succeeded by an undulatory movement from behind forwards of the remaining part of the scaphognathite. As the crab lay on its back the anterior lobe could finally be seen to descend slowly and gently upon the anterior edge of the roof of the chamber, gliding along, and, as it were, stroking its polished surface.

When the current is reversed, however, the action of the anterior lobe is quite different; it strikes the water in front with a prompt, decisive blow, and this is succeeded by an undulatory movement of the rest of the scaphognathite from before backwards. The water lying between the valve and the roof of the chamber is thus driven backwards into the branchial cavity. The action of the scaphognathite is fairly rapid, but after a little observation, checked by the employment of coloured water to test the currents, it becomes quite easy to detect with certainty the direction of the current by inference from the movements of the scaphognathite alone.

The action of the exopoditic palps of the maxillipeds in causing currents has already been described. Such currents are purely accessory, and Gosse (1865, p. 130) and De Haan (1850, p. 117) have undoubtedly erred in assigning to the maxillipeds an important share in the production of respiratory currents.

V. EVOLUTIONAL SIGNIFICANCE.

The habits of *Corystes cassivelaunus* described above seem to me to demonstrate the adaptive nature of the entire organization of this Crustacean, and slight consideration is all that is required to enable a naturalist to recognise the utility of these adaptive features.

The burrowing habit is useful as a mode of concealment from enemies. The elongation and smoothness of the carapace, and the elongated claws of the four hindmost pair of thoracic legs, are all features usefully correlated with the specialization of the crab for a sand-burrowing existence.

The elongation of the antennæ and the arrangement of the hairs upon them, the double bend of their basal joints, the structure of the parts bounding the prostomial chamber, and the arrangement of hairs upon them, are characters which, in conjunction with the reversal of the respiratory current, adapt the respiratory mechanism of the crab in a remarkably complete manner to an arenicolous mode of life. The antennal tube enables the crab to draw its supplies of water directly from the superincumbent reservoir of water, while the arrangement of hairs is such as to constitute a sieve, keeping the sand away from the respiratory organs.

The upright position of the crab is itself a most unusual feature, and is correlated with the formation of an elongated antennal tube; the posterior position of the legs is functionally correlated with the adoption of the upright attitude.

VI. ANALOGIES.

A reversal of the respiratory current similar to that which I have just described in *Corystes* also takes place under certain conditions in the allied form *Atelecyclus heterodon.* The habits of this crab are much more complex than those of *Corystes,* and will form the subject of a later article.

An elongation of the antennæ, and their conversion into an antennal tube by the interlocking of hairs along their margins, also takes place, as I have recently discovered, in an East Indian Crustacean, *Albunea symnista*, Fabr., which belongs to the Hippinea among the Macrura Anomala (Anomura). In this type, however, the antennal tube is formed by the first and not by the second pair of antennæ. The antennal tube has obviously been produced independently in *Corystes* and *Albunea*, and affords a remarkable example of homoplastic modification. In all probability the function of the tube is the same in both cases, but no direct observations on this head in the case of *Albunea* have yet been made.

It seems to me not unlikely that further observation of the habits of *Hippa talpoida* of the American coasts will reveal an essentially similar sieve-like function for the curiously bent and setose second antennæ of that animal.

BIBLIOGRAPHY.

Bell, T. (1853).—*British Stalk-Eyed Crustacea*, pp. 159-163.

Couch, J. (1878).—*Cornish Fauna*, 2nd Ed., pp. 75, 76.

Dana, J. D. (1852).—"Crustacea." *U.S. Exploring Expedition*, vol. xiii.

Gosse, P. H. (1865).—*A Year at the Shore*, pp. 127-131.

Haan, W. de (1850).—"Crustacea." *Siebold's Fauna Japonica.*

Hunt, A. R. (1885).—"On the Influence of Wave-Currents on the Fauna inhabiting Shallow Seas." *Proc. Linn. Soc.*, xviii. *Zool.*, p. 269.

Miers, E. J. (1886).—"Brachyura." *Challenger Reports*, vol. xvii.

Milne-Edwards, H. (1834).—*Histoire Nat. des Crustacés*, 3 vols.

,, (1839.) "Recherches sur le Mécanisme de la Respiration chez les Crustacés." *Ann. Sci. Nat.* (2) xi. pp. 129-142.

Robertson, David (1861).—"On the Uses of the Antennæ of *Corystes cassivelaunus.*" Proc. Philosoph. Soc. Glasgow, v., completed 1864, pp. 55, 56 (with a good figure).

,, (1886-88).—*Proc. and Trans. Nat. Hist. Soc. Glasgow*, ii. (*N.S.*), pp. 143, 144.

Stebbing, T. R. R. (1893).—"A History of Crustacea." *Int. Sci. Series.*

Physical and Biological Conditions in the North Sea.

By

J. T. Cunningham, M.A.

SUMMARY.

PAGE
Results of Professor Otto Pettersson's investigations of the conditions and movements of the various layers of water in the Skagerack and Cattegat, and the influence of these conditions and movements on the migration of fishes. Southern Species entering the Baltic with coast water from the south, Northern Species with coast water from the north 233
Mr. H. N. Dickson's observations in the Faröe-Shetland channel and the northern entrance of the North Sea, and the conclusions he draws from them. Suggested influence upon the migration of fishes of the amount of oxygen in sea-water . 237
Mr. Dickson's paper in the *Geographical Journal* for March, 1896, describing the surface salinities and temperatures observed in the International Hydrographic Survey of 1893-1894 243
Actual peculiarities in the distribution of fishes in the North Sea . . . 246
Southern Species entering the North Sea from the south 247
Probable dependence of the immigration of Southern Species on temperature . . 249
Southern Species entering at the north. All those found in the south, and a great many more occur on the south coast of Norway, though all do not enter the Baltic. Their presence in this neighbourhood due to the warm Atlantic surface drift, or Gulf Stream 252
Distribution of Northern Species. These species principally occur in the deeper water along the east coast of Britain 255
The general physical conditions determining the distribution of Northern Species . 257
The migrations of the herring 259
Different sizes of fish of the same species at different parts of its habitat . . 260

In my report, in the preceding number of this Journal, on my observations in the North Sea, I referred briefly to the problem of the relation between the physical and biological conditions. This problem will afford scope for investigation for some time to come, and the purpose of the present article is to discuss and compare some of the most recent additions to our knowledge of the matter. The paper by Mr. H. N. Dickson, to which I referred in my previous report, was published in the *Geographical Journal* last March, under the title of "The Movements of the Surface Waters of the North Sea," and in the *Scottish Geographical Journal*, in 1894, was published a series of papers by Professor Pettersson on "Swedish Hydrographic Research in the Baltic and the North Seas." Professor Heincke has discussed the fish fauna of Heligoland, its composition and sources, in an interesting paper in the series issued under the title of "Wissenschaftliche Meeresuntersuchungen," by the staff of the Biological Station at Heligoland, in association with the Commission for the Investigation of the German Seas, at Kiel. Professor Heincke's paper is contained in Bnd. I., Hft. 1 of this series (1894), and in the same volume are a number of papers dealing on similar lines with other divisions of the marine fauna of the Heligoland Bight.

It will be most convenient and logical to start the present discussion with a consideration of the results of Professor Pettersson's work. He found that the Skagerack and Cattegat were filled with layers of water distinguished from one another by differences of salinity, and that the lower layers entered the channel as under-currents, and could be recognised at the surface somewhere in the North Sea.

The different waters he distinguishes are the following:

1. Ocean-water of 35 per thousand salinity or more.

2. Water of from 34 to 35 per thousand salinity. On account of its extension over a great part of the North Sea, this is called North Sea water.

3. Water whose salinity is 32 to 34 per thousand. This forms a broad edging along the coasts of Holland, Germany, Denmark, and Norway, and is named by Pettersson "bank-water." I shall prefer to distinguish it for the present purpose as coast water.

4. Water from 30 to 32 per thousand salinity, or less, belonging to the outflowing stream from the Baltic.

The numbers of course signify the parts of salt by weight in a thousand parts of the water.

Now, the oceanic water fills the central part of the North Sea as far as the Dogger Bank from bottom to surface. Towards the east it does not reach to the surface, but fills the bottom of the deep channel which extends along the Norwegian coast and into the Skagerack.

The North Sea water is found in the North Sea south-east and west of the Dogger Bank, and along the coasts on each side of the North Atlantic Ocean. In the Skagerack it lies over the oceanic water, and is not found at the surface, except in a band along the north coast of Denmark. The North Sea water flows into the Skagerack principally in spring and summer.

The coast water flows into the Skagerack most abundantly in autumn and winter, when it reaches a considerable thickness, and predominates at the surface in the central part of the channel. In summer time the quantity of this water present is very much reduced. It is then displaced by Baltic water.

The cause of the difference in the amount of the influx cannot be other than the periodic variation in the outflow from the Baltic. When the Baltic outflow decreases, coast water flows into the Skagerack, where it is found as a thick and relatively warm surface layer in the coldest months of the year. When the outflow of Baltic water increases in spring and summer, the coast water is swept out of the Skagerack again, and at the same time the deeper waters begin to flow in and swell in volume. Professor Pettersson attributes the latter inflow to a reaction upon the deeper strata in the North Sea, due to the energy stored up in the waters of the Baltic, but I must confess that for my comprehension these expressions require further explanation. The annual variation in the Skagerack affects the water to a depth of about 50 fathoms.

The temperature of the North Sea water varies inversely with that of the season; it is the coldest water of the Skagerack in summer, and the warmest in winter.

The North Sea water varies much in the amount of dissolved oxygen which it contains; in July, 1890, it was very deficient in oxygen, while in September, 1893, it was supersaturated with that gas, a condition which has only been found to occur in surface waters from high latitudes.

The North Sea water begins to flow into the Skagerack in May, and its entrance coincides with the commencement of the mackerel fishery on the Swedish coast. There seems to be a certain connection between the expansion of the volume of 34 per cent. water in the Skagerack, and the appearance of the mackerel and gar-fish.

The temperature of the coast water, on the other hand, and still more of the Baltic water, varies with that of the season.

The coast water may flow into the Skagerack from two directions, namely, either from the south along the coasts of Denmark and Germany, or from the north along the coast of Norway. This is important, because there are reasons for believing that the coast water has two periods of influx. The first influx occurs in August and September, and is due to the influence of westerly gales. At this time of the year warm water, whose temperature reaches 15° or 16° C., and whose salinity is 32 to 33 per cent., sets in along the north-west coast of Jutland. It fills the central part of the Cattegat from top to bottom as far to the south as a point between Trindelen and Anhalt, and then dips under the Baltic water.

In early autumn the herring fishery, with floating nets, in the Cattegat and south Skagerack, coincides with this influx of coast water. In a subsequent part of his paper, Pettersson points out that Möbius and Heincke, in their memoir on the Fishes of the Baltic, state that there are 32 species, of which specimens occur in the Western Baltic occasionally, and are not resident there. These fish are immigrants, and 18 of the species are southern forms—that is, forms whose range extends from the Mediterranean to the British Islands, but not to the Arctic Circle, while of the remaining 14 species, 10 are northern forms—that is, species which are abundant within the Arctic Circle, but do not occur in the Mediterranean. The occurrence of the southern forms in the Baltic takes place chiefly in September and October, and, therefore, coincides with the inflow of the southern coast water. The species in question are:—

Labrax lupus, the Bass; *Sciaena aquila*; *Mullus surmuletus*, the Red Mullet; *Brama Rayi*, Ray's Bream; *Thynnus vulgaris*, the Common Tunny; *Xiphias gladius*, the Sword-fish; *Trigla hirundo*, the Tub, or Latchet; *Mugil chelo*, the Grey Mullet; *Labrus maculatus*, the Spotted Wrasse; *Crenilabrus melops*; *Gadus minutus*, the Poor Cod; *Merluccius vulgaris*, the Hake; *Solea vulgaris*, the Common Sole; *Orthagoriscus mola*, the Sun-fish; *Engraulis encrasicholus*, the Anchovy; *Conger vulgaris*, the Conger; *Carcharias glaucus*; *Trygon pastinaca*.

Now, we cannot consider the herring as a southern fish. It is very improbable that herrings enter the North Sea from the English Channel: on the contrary, the evidence points the other way—namely, to the conclusion that the North Sea herrings come from the north; and the association of herrings with southern coast water is a fact which requires further examination. Pettersson does not discuss the difficulty.

In January, February, and March, the coldest season of the year, there is an influx of water of the same salinity as that previously mentioned—namely 32 to 33 per cent., but of a temperature of only 4° to 5° C., which evidently comes from the north along the Norwegian coast. In 1893 this northern coast water was entering the Skagerack in November, and it was found to contain a very characteristic Plankton, or assemblage of minute swimming forms, entirely different from that of the adjacent water of the Baltic current. The latter consisted chiefly of vegetable organisms, such as Diatoms, Cilio-flagellates, etc., intermixed with Copepods, such as *Centropages hamatus*, which occur also in the Cattegat and Baltic up to the Aland Islands, at the entrance of the Gulf of Bothnia.

In the northern coast water, on the contrary, vegetable Plankton was scarce, and the animals were of Arctic or North Atlantic origin, which never appear in the Skagerack during summer, *e.g.*:—

Euphausia inermis (Kröyer) (*Schizopod*); *Hyperoche Kröyeri* (Bovallius) (*Amphipod*); *Parathemisto oblivia* (Kröyer) (*Amphipod*); *Diphyes truncata* (M. Sars) (*Siphonophore*).

The first-mentioned is known to be the principal food of the great whale, *Balenoptera Sibbaldii*, and is most abundant between Varanger Fjord and the Lofoten Islands. The herring fishery was then going on in the neighbourhood of Lysekil. Only 33 per cent. of the herrings caught had any food in their stomachs, and it consisted of 15 forms of animal Plankton, of which the remains of *Limacina balea* was the most remarkable. This Pteropod frequents chiefly the North Atlantic and Arctic Ocean, and occasionally appears on the west coast of Norway, where it is greedily devoured by herrings. As not a single specimen of the species was found in the waters of the Skagerack in November, the shells of the *Limacina* in the stomachs of the herring must have been a remnant of the food swallowed by the fishes outside the Skagerack. The winter herring are caught in water of the kind denoted here as northern coast water, and disappear with it.

The northern species of fish mentioned by Möbius and Heincke as occurring occasionally in the Baltic are :—*Liparis Montagui*, Montague's Sucker; *Anarrhichas lupus*, the Cat-fish; *Stichaeus Islandicus*; *Gadus pollachius*, the Pollack; *Hippoglossus vulgaris*, the Halibut; *Pleuronectes cynoglossus*, the Witch; *Gadus virens*, the Coal-fish; *Lota molva*, the Ling; *Raia radiata*.

According to Pettersson these northern fishes are only found in the Western Baltic in the early part of the year, that is to say, chiefly in January, February, and March, during the time when, as he has proved, there is an inflow of coast water of a temperature of 4° to 6° C. along the south coast of Norway into the Skagerack and Cattegat.

Having analysed with so much success the composition of the waters entering and leaving the Baltic, Professor Pettersson and the Swedish hydrographers associated with him, conceived the project of extending the application of their methods to the whole of the North Sea, in order to distinguish the different waters entering and leaving that basin, and to trace them to their sources. Proposals were accordingly made to the governments of other countries bordering the North Sea, that they should take part in an international co-operative hydrographic survey. On behalf of Britain the Scottish Fishery Board undertook to survey the region to the north and east of Scotland. In accordance with the plans arranged, H.M.S. *Jackal* was employed in the work, and Mr. H. N. Dickson, F.R.S.E., was entrusted with its execution. Four expeditions to the northern entrances to the North Sea were made—in August and November, 1893, and in February and May, 1894. The results of the observations are recorded in detail in the Twelfth Report of the Scottish Fishery Board; and in *Natural Science* for January, 1895, Mr. Dickson published an article in which he discussed the probable influence of the movements of water which had been ascertained to occur, on the migrations and distribution of fishes, and consequently on fisheries.

Mr. Dickson regards the subject in a manner which seems to me peculiar; and while his work in the physical department is well known to be in all respects admirable and sound, I am obliged to express some disagreement with the argument he employs concerning the biological questions. He urges that we cannot discover direct hard and fast relations between the temperature or the salinity or the density of sea-water, and the constant or periodic occurrence of certain animals (*e.g.*, fishes) in particular localities. Yet we have to discover some reason for the fact that the appearance of certain fishes and other marine animals has been frequently observed to be associated with a periodical change in the temperature or salinity of the water. Mr. Dickson says that the peculiarities of temperature or salinity are certainly too slight to seriously affect animal life. But he points out that it is just these two physical elements upon which the oceanographer relies in tracing the circulation of waters, and in identifying the sources from which they are derived.

He proceeds to lay stress upon the alleged fact that Pettersson and his colleagues have collected a mass of evidence shewing that the migrations of herring and mackerel, and other variations in the distribution of not only fishes, but Plankton, are dependent on the amount of oxygen present in the sea-water. The amount of oxygen dissolved in the water depends solely on the temperature and atmospheric pressure to which it was exposed when at the surface. The lower layers of water, in enclosed areas, are accordingly liable to become deficient in oxygen, and fresh supplies must be obtained by mixture with water from the ocean, if animal life is to remain healthy and abundant.

Now, after careful study of Pettersson's papers in the *Scottish Geographical Magazine*, I cannot perceive that they exactly correspond to Mr. Dickson's description. According to Pettersson, the advent of the mackerel corresponds to the influx of North Sea water in May and the following summer period. During winter the amount of North Sea water present in the Skagerack decreases, and that which remains becomes deficient in oxygen. But it is scarcely possible to hold that the deficiency of oxygen in this layer of water alone causes the mackerel to leave. For in the first place mackerel swim very near the surface, and are therefore not, in all probability, contained in the North Sea water at all, but in the overlying Baltic water, which in summer flows out through the Skagerack in considerable quantity. Then, again, the herring enter the Skagerack, according to Pettersson, in autumn and winter, with the influx of coast-water from the north.

If it were a mere question of oxygen, there would be no reason why the mackerel should migrate to the Swedish coast in summer, and the herring in winter. Moreover, the coast-water flows in at the surface, and displaces the Baltic current in winter, and so far from being richer in oxygen, contains less of that element than the surface water of the Baltic. In a foot-note on the latter, Pettersson states:—

"This singular fact that the waters of the Baltic upper layers may occasionally be supersaturated with oxygen like Arctic water, is worthy of attention. I have discussed this phenomenon with the eminent specialist on diatoms, Professor Cleve of Upsala. We both arrived at the conclusion that supersaturation with oxygen, as well as deficiency of oxygen, is probably due to the influence of organic life. The predominance of vegetable Plankton, which is characteristic of Arctic as well as of Baltic water, may cause the former, the respiration of animals and of animal Plankton the latter phenomenon.

"Be this as it may, it is certainly a fact to be borne in mind by biologists, that the conditions of organic life are very different in the Baltic and in the North Sea, on account of the relatively high amount of dissolved oxygen in the upper layers of the Baltic. Owing to the low salinity, the perfect aeration of the water down to a considerable depth, and the low temperature at which their water is saturated with air in winter, the upper layers of the Baltic contain about 30 per cent. more oxygen than the waters of the North Sea."

In view of the above statement, it can scarcely be maintained that the visits of migratory fish, like herring and mackerel, to the mouth of the Baltic, are to be attributed to the abundance of oxygen present in the sea-water which flows into the entrance of that sea at certain seasons of the year.

What Pettersson does prove with regard to the herring is, that its presence on the west coast of Sweden depends on the presence of water having certain qualities, and derived from a certain source. In the fifth of his series of papers, in the *Scottish Geographical Journal* for 1894, there is a special discussion of the changes in the water on the west coast of Sweden, and their effect upon the herring fishery. In 1877, after an absence of seventy years, herring again appeared on the Swedish coast. It appears to be a historical fact that, time after time, herring have entirely deserted this coast, have remained absent for a period of about seventy years, and have then resumed their annual migration to the region, giving rise to a valuable and important fishery. The cause of this regular irregularity does not concern us here, nor is it discussed by Pettersson; we are considering merely Pettersson's conclusions concerning the changes in the water which determine the arrival and departure of the herring on the coast during the period when it pays its annual visit. In the middle of December, 1878, before the herring had appeared, the salt-water of 34 per cent. salinity (North Sea water) reached to within fifteen or twenty fathoms of the surface, and filled the deep channels of the coast. The surface water overlying this consisted of layers of 32 and 33 per cent. salinity, evidently the remnant from the inflow of coast-water in autumn; the temperature of this was 8° to 9° C.

In the latter part of December stormy weather occurred, and a new influx of coast water took place, of the same salinity, but with a temperature of only 4° to 6° C. The last influx of this water occurred on the 28th and 29th December, and simultaneously the herring fishery began on the coast to the east of Wädero Islands. In the middle of January the fishery began to decline at the same place, the cause of which was as follows: On the 11th and 12th January the wind, which had been blowing from the N.E., began to blow from S. and S.E., in consequence the fresher and colder water belonging to the Baltic stream began to flow northwards along the Swedish coast, and as the Baltic water displaced the coast water the herring disappeared. There can be no suggestion here of a superiority in the supply of oxygen in the coast water. Both the water with which the herring came, and that which drove them away, were surface waters, and both well supplied with oxygen, especially the latter. The difference between the two consisted chiefly of salinity and temperature, and the effect upon the fish may have been due rather to the movement of the water than to its qualities.

On the other hand, it is perfectly correct that Pettersson has discussed in considerable detail the absence of oxygen in the bottom water contained in deep depressions separated by higher ground from similar depths in the neighbourhood. In such cases the water contained in the depression is salter, and therefore heavier than the overlying water, and remains undisturbed and unaffected by the movements of the lighter and fresher water passing over it. When deprived of the dissolved oxygen which it contains, the bottom water, being cut off from contact with the air, can obtain no new supplies, except what it takes up by diffusion from the layers of water above it, and that is scarcely any. The oxygen originally contained in it is constantly being abstracted by the respiration of the animals that live in it, and by algae also in the absence of light, so that if undisturbed for a long time water in an isolated depression becomes almost entirely destitute of oxygen, and, therefore, incapable of supporting animal life. Pettersson states that these are the conditions to which the deep basins of the fjords on the west coast of Sweden are subjected, because the bottom of the fjords is much higher and nearer the surface of the water at the entrances than at the inner parts, so that below a certain depth the water in the fjords is cut off from communication with the water in the open sea. The Gullmar Fjord is described as a typical example. The depth of water on the Swedish coast bank, *i.e.*, from the shore of the mainland as far as the outermost rocks and shoals, does not usually exceed 15 fathoms. But corresponding to each fjord, leading from its entrance towards the S.W. there is a deeper channel, cut off from the deep inner basin of the fjord by the ridge across its mouth.

In summer the ocean water and the North Sea water in the Skagerack extend from the bottom nearer to the surface than in winter, and above the North Sea water lies the Baltic water, which flows out most abundantly in summer. On the declivity of the coast the layer of Baltic or fresh water is deeper than in the central part of the Skagerack. In consequence of these facts the ocean water never enters the Gullmar Fjord, because its level never reaches to within 20 fathoms of the surface on the coast declivity, and that is the depth of the ridge at the entrance of the fjord. The North Sea water, however, whose salinity is 34 per 1000, enters the fjord occasionally, or periodically, and it is water of this salinity which fills the inner basin of the fjord. Waters of 33 per 1000 and less flow into or out of the fjord from the surface to the depth of 20 fathoms at all seasons of the year.

It was found that the bottom water of the Gullmar Fjord in February, 1890, was extremely deficient in oxygen, that it was cut off from communication with water of the same salinity outside, which contained plenty of oxygen. In June, 1890, the level of the North Sea water outside the fjord rose to less than 20 fathoms from the surface, flowed over the ridge, and displaced or mixed with the stagnant water already there. This did not happen again until 1893.

The Gullmar Fjord is noted for the fishery for cod and John Dory in its deep water, a fishery which takes place in winter, but not every winter. In the winter of 1889–90 this fishing was very poor, and had been so for some previous years. In the winter of 1890–91 it was very successful. The inference suggested is that the entrance of these fish into the Gullmar Fjord is dependent upon the entrance of North Sea water in summer, which does not always occur. When it does not occur, even if the fish should enter the fjord by swimming over the bar at the entrance, the bottom water of the fjord would be nearly or quite uninhabitable for them on account of the small supply of oxygen it contains. Pettersson expressly points out that he does not consider the herring fishery in the fjord to be affected by this change in the bottom water, but believes it to be dependent upon the inflow of coast water at the surface, in the manner which has already been described.

The general results of Mr. Dickson's own investigations of the conditions and movements of the sea-water to the north of Scotland were as follows. Between the Faröe and Shetland Islands and the submarine elevations of which they are the highest points, is a narrow submarine valley extending from the deep basin of the Norwegian Sea. This valley is separated at its south-western end from the deep basin of the Atlantic by the Wyville Thomson ridge, which is only 300 fathoms from the surface of the sea. Over this ridge the water of the Atlantic flows throughout the year towards the north-east, its movement being caused by the cyclonic winds in winter and by the greater warmth and consequent higher level of the Atlantic water in summer as compared with the Norwegian Sea. The Atlantic water flowing over the ridge sucks up the cold water from beneath, and mixes with it. Owing to its greater saltness the Atlantic water thus cooled sinks and loses its velocity. The influence of the earth's rotation deflects the current to the right, and thus in summer a mass of Atlantic water tends to collect on the north-western and northern edge of the North Sea bank. At all seasons this water enters with the tides between the Orkneys and Shetlands, but in winter, westerly winds drive it towards the east, and none passes down the east coast of Britain. But in summer, when the winds are light, and the surface layers of the North Sea are warmer and lighter, the Atlantic water mixes with the cold bottom water of the North Sea, and finds its way along the east coast of Scotland. The causes by which, according to Mr. Dickson's explanation, this is accomplished, I do not profess to fully understand. The explanation given is that the Atlantic water collected at the edge of the North Sea bank mixes with the cold bottom water already there, and increases its salinity but reduces its specific gravity by warming it. At a certain stage of mixture the temperature and salinities of the two waters combine to form an axis of maximum specific gravity. This axis, which probably runs N.E. from Shetland at the end of May or in June, turns slowly toward a N. to S. direction and moves eastward. As it retreats, Atlantic water is gradually admitted round the north end of the Shetlands, passes down the east side of the islands, joins the tidal stream at the south end, and guided by the axis of heavy water, is distributed along the east coast of Scotland probably during July and August.

In his essay in *Natural Science*, Dickson states that it is in the oceanic or Atlantic water, thus admitted in summer down the east coast of Scotland, that the summer and autumn herring fishery takes place, and remarks that whether this fresh supply of oceanic water really does contain a markedly greater amount of oxygen than the water it replaces can only be ascertained by actual analysis (which was not carried out), and that the further question, whether the herring comes with this water or to it, must be settled by zoologists.

In his paper on "The Movements of the Surface Waters of the North Sea," published in the *Geographical Journal* for March, 1896, Mr. Dickson tells us that in the International Hydrographic Survey, in 1893 and 1894, Denmark, Sweden, Germany, Scotland, and Norway took part. The plan was to obtain simultaneous observations in different parts at times arranged beforehand. In May, 1893, Danish and Swedish ships were at work; in August and November, 1893, and February and May, 1894, ships from the Kiel Commission and the Fishery Board for Scotland co-operated; while a Norwegian vessel also made observations in the latter periods. Mr. Dickson gives a summary of all the observations so far as they refer to the surface waters, combining with them observations made on merchant vessels, obtained from Professor Pettersson and from the Meteorological Office in London.

In his preliminary remarks Mr. Dickson points out a fact which, obvious enough in itself, is of great importance, namely, that the original sources of the water in the North Sea are the oceanic waters entering from the north and north-west, and, to some extent also, from the Straits of Dover, and land waters entering from the Baltic and the rivers. The other waters, distinguished and appropriately named by Pettersson, are due to mixture of these two. In a large and deep basin the fresher water would overlie the ocean water, and mixture would take place slowly; but in a shallow basin like the North Sea the influences of wind and tide penetrate to the bottom, and mixture sometimes takes place with great vigour and rapidity, so that North Sea water (34 to 35 per thousand) sometimes occupies almost the entire basin. The varying temperatures of the seasons and the force of winds are very important local influences governing the distribution of the different waters.

Descriptions are then given of the distribution of the various waters as distinguished by Pettersson in May, August, and November, 1893, and in February and May, 1894. The distribution is well shown on the series of coloured maps, one showing the salinities, the other the temperatures of the surface waters. Perhaps the most important point to notice at the different periods is the distribution of oceanic water, which enters from the north southwards, and from the Straits of Dover northwards, but the temperatures are also, in relation to the distribution of fishes and other animals, of great importance.

At the beginning of May, 1893, oceanic water covers a small area well to the north and north-east, forming a central tongue terminating opposite the entrance of the Baltic, and an isolated patch between East Anglia and the Dutch coast. The rest of the North Sea is covered by North Sea water, except a narrow edging along the continental coast extending some distance into the Skagerack; this is coast water. The isothermals, or lines of equal temperature of the surface water, are interesting at this period. At the western entrance of the English Channel we have 12° C., which diminishes as we pass up the Channel, but the limit of 9° C. passes from the islands outside the Zuyder Zee to a point on the English coast about Flamborough Head. North of this we have only 8° and then 7°, a band of the latter extending from about Aberdeen to the Baltic and along the Norwegian coast, while north-west of this we have again 8° and 9°. Along the whole of the western coast of the British Islands, the Atlantic temperature is 9° and 10°. The influence of this distribution of temperature alone, on the distribution of southern species of animals, cannot, I think, be over-rated, as will be seen below when the distribution of animals is considered. The distribution of animals is not discussed at all by Dickson in the paper with which we are now dealing.

In August, 1893, the northern tongue of oceanic water is broader and extends further southward, reaching to the edge of the Dogger Bank, while in the south a tongue from the Straits of Dover extends to the latitude of Lowestoft. The band of coast water along the German and Danish coasts is somewhat broader, but it does not extend into the Skagerack; we now see the Baltic current or stream flowing out in full force, extending northwards along the Norwegian coast in a broad band. This Baltic water is now, owing the influence of the sun on the land, of higher temperature than any other part of the surface of the North Sea, except two isolated patches near the British coasts. The whole of the North Sea (surface) is now as warm as the Atlantic water on the west coasts of the British Islands. Both in the North Sea and on the west coasts, the temperatures diminish from south to north from 18° to 13° C., but a narrow tongue of colder temperature extends southward, so as to include the Orkney and Shetland Islands and part of the Moray Firth.

In November, 1893, the northern tongue of oceanic water is broader, but does not extend further south; the southern tongue extends a little beyond the Texel. The outflow of the Baltic stream has ceased, and coast water is seen in the map extending along the south-west coast of Norway and entering the Skagerack, in the manner previously described by Pettersson.

The temperature of the surface water is now lowest in a band along the coast of Holland, Germany, and Denmark, corresponding closely with the extent of the coast water, where it is 8°. This same temperature extends from the coast of Norway to the east coast of Scotland, and the Orkneys and Shetlands. The rest of the North Sea is 9° and 10° C., becoming warmer towards the English Channel, at the western entrance of which we have 11° to 13°. On the west coasts of the British Islands the temperature is 9° and 10°, as in the south-western part of the North Sea. Mr. Dickson observes that the low temperature on the east coast of Scotland at this period corresponds to the up-welling of bottom water which has been observed there.

In February, 1894, we find that the northern and southern tongues of oceanic water have met and joined, so that there is a broad central region of this water extending completely through the North Sea. North Sea water occupies a narrow strip on each side, and extends in a narrow tongue into the Skagerack. Coast water is seen on the south coast of Norway, extending into the Skagerack as far as the Skaw, and as usual in a narrow band along the east coast of the North Sea.

Surface temperature is now at its lowest for the year. From the east coast of the North Sea nearly to the middle it is only 4° C., this temperature extending all over the Heligoland Bight. Over the whole of the western part of the North Sea the temperature is only 5° and 6° C. On the west coast of the British Islands we have temperatures of 7° and 8°, including the western entrance of the English Channel, but 9° and 10° are found not far to the westward in the Atlantic.

The yearly cycle has now been completed, but we have also observations and charts for May, 1894, and these show that the conditions of May, 1893, are not exactly repeated. It would naturally be expected that the same conditions do not recur exactly at the same period every year, if ever, though there must be a general similarity in successive years. In May, 1894, the data are incomplete, but they show that oceanic water extended throughout the central part of the North Sea, as in the preceding February, with a narrow band of North Sea water on each side. The temperatures are more similar to those of May, 1893, but are rather higher, that of 8° C. extending over nearly the whole of the northern part of the North Sea, while, as in the earlier period, the temperature of 9° extends on the west coast of our islands beyond the north of Scotland.

Professor Pettersson has also mapped the distribution of surface salinity over the greater part of the North Sea at the end of November, 1894, and the middle of February, 1895. In November, 1894, the total area occupied by oceanic water was but small, and the Baltic outflow, instead of being cut off, as at this time in 1893, extended far to the northward. Absence of winds may account for the weakness of the oceanic streams, and the greater strength of the Baltic stream is ascribed to the mildness of the season.

Mr. Dickson adds a discussion of the forces at work in producing the observed conditions and changes, taking separately the local forces in the North Sea and the external. He finds that the chief influence at work locally is the wind. His conclusions are that the existence of a continuous strip of oceanic water along the central axis of the North Sea, is due to westerly and south-westerly winds strengthening the oceanic current. Strong northerly winds tend to broaden the northern area of oceanic water, and to blunt its extremity, and also have the effect of sending coast water southwards along the west coast of Norway: it is probable that this is the cause of the inflow of coast water into the Skagerack. Calm weather favours the spread of North Sea water over a great part of the North Sea, while easterly and south-easterly winds spread the fresher waters of the east side of the sea over the surface.

With regard to the inflowing or oceanic waters, as they are all of about the same salinity, Mr. Dickson infers their movements from the different temperatures. He finds that the Atlantic streams are on the whole strongest in summer, but the cold streams moving southwards from the eastern coasts of Iceland and Greenland are also strongest in summer. It is a mixture of the two which takes place in the Faröe-Shetland Channel, and this mixture is driven into the North Sea in the manner already mentioned.

I do not think that, for my present purpose, it would be of much advantage to give a more detailed account of Mr. Dickson's discussion of the physical conditions. He does not enter upon their relation to the migrations and distribution of fish, and it seems to me that, with respect to this relation, the changes and distribution of actual temperature and salinity in detail are of more importance than the forces by which these changes are caused. The points of view of the physicist and the biologist are different. The former is chiefly interested in tracing the causes of the observed movements of waters, regarding temperature and salinity rather as qualities by which the different currents are to be identified. The biologist's business, on the other hand, is to ascertain how the degrees of temperature and salinity affect the migrations and distribution of different species of fish. It must be understood, therefore, that in this paper I have, to a large extent, expressed conclusions of my own concerning the relation of the observations published by the physicists to those made by zoologists.

We have then to consider more particularly what is known concerning the actual distribution of fishes and other animals in the North Sea, and the waters communicating with it. With regard to two well-defined portions of the regions, namely, the Baltic and the Heligoland Bight, the facts have been collected and analysed in a very interesting manner by the German naturalists associated with the Kiel Commission, and the

Biological Station on Heligoland. The fish of the Baltic have been considered by Möbius and Heincke in a paper* which has already been cited, while Fr. Heincke alone has treated the fishes of the Heligoland Bight in a similar manner.† Papers on the other animals of these districts are also contained in the publications of the same institutions. For the rest of the region I have to rely on various ichthyological works, and on my own experience.

The peculiarity in the general distribution of fishes in the North Sea is that southern species are found along its eastern side, and at its northern as well as its southern entrance, but are absent on its western shores, and in its central and western portion. The reason of this, as Heincke points out, is that there are two routes by which southern species can enter the North Sea, namely, that of the Gulf Stream—the drift of Atlantic surface water which bathes all the western coasts of the British Isles, flows past the Shetlands to the coast of Norway, and sends a twig into the Baltic; and secondly, the route which leads from the English Channel, a slow stream of southern warmer water passing along the Dutch and other continental coasts.

SOUTHERN SPECIES ENTERING THE NORTH SEA FROM THE SOUTH.

In discussing distribution it is necessary to distinguish between littoral species, which inhabit the zone of sea-weeds, surface species, which feed and swim in the open water, and bottom species, which feed on the bottom; Heincke uses for the latter two divisions the terms aperticolous and fundicolous. He also distinguishes three divisions according to the frequency of their occurrence, namely, common resident species, rarer resident species, and occasional immigrants. We do not know with sufficient completeness the seasonal movements of the majority of fishes in a particular locality, but there is evidence to show that the aperticolous species are most migratory, the fundicolous less so, and the littoral species least of all. It is fairly certain that aperticolous southern species enter the North Sea from the Straits of Dover only in summer, and that they retire in winter. The aperticolous southern forms found in the Heligoland Bight are *Scomber scomber*, the Mackerel; *Caranx trachurus*, the Scad; *Belone vulgaris*, the Gar-fish; *Merluccius vulgaris*, the Hake; *Thynnus vulgaris*, the Tunny; *Engraulis encrasicholus*, the Anchovy.

---

* Fische der Ostsee. *Vierter Bericht der Commission zur Untersuchung der deutschen Meere*, 1883.

† *Wissenschaftliche Meeresuntersuchungen herausgegeben von der Kommission zur Untersuchung der deutschen Meere, und der Biologischen Anstalt auf Helgoland, Neue Folge, Erste Band, Heft* 1, 1894.

Heincke places the mackerel among the common resident forms, and in general only considers the comparative abundance and rarity of the forms, while I am endeavouring to trace the relation between the temporary and permanent presence of certain species on the one hand, and temporary and permanent physical conditions on the other. The anchovy, according to Heincke, has not been yet found at Heligoland, but we know that it is abundant in summer in the Zuyder Zee, and Ehrenbaum found its pelagic ova further to the east near the Island of Nordeney.

We must remember that these forms might reach the Heligoland Bight from the north, since all of them occur in the Skagerack and Western Baltic. It is probable that the hake does come from this direction, as it is a deep-water fish, and has scarcely ever been taken in the shallow part of the North Sea south of the Texel; it is not mentioned in Van Beneden's "Fishes of the Coast of Belgium."* It is not common in the Heligoland Bight, being placed by Heincke among the rarer residents. The tunny is still more rare, and is classed by Heincke as an occasional visitor. It probably comes both from the south and the north, as it has been occasionally taken on the coast of Kent and of Norfolk. But on the whole, as it is an oceanic fish, it is more likely to reach Heligoland from the north. The other four species are more important, because they visit the region in question in greater numbers, and they undoubtedly come from the south through the Straits of Dover, appearing regularly every summer in the narrow southern part of the North Sea between the coasts of Holland and Belgium and the English coasts, as well as on the south coast of England. The anchovy, however, is practically absent from the English side north of Kent.

All these four species are so scarce as to be practically absent along the east coast of England, but become somewhat more abundant towards the north along the east coast of Scotland, owing clearly to their incursion from the north.

Although more complete observations are required concerning the time at which these fish are present in the southern and eastern part of the North Sea, we have evidence that they occur there only in summer and autumn, and disappear in winter. Mackerel fishing at Lowestoft begins at the beginning of May, and lasts till the end of June, and there is a second or autumn fishery in September and October. It is difficult to understand why these fish are not present in the same neighbourhood in July and August. Van Beneden states that the scad appears regularly on the coast of Belgium towards the end of April, before the arrival of the mackerel. The gar-fish occurs at the same time as the mackerel: in the Schelde it is taken with the anchovies in May and June; I have seen it at Brightlingsea in the same two months, and I also saw several specimens brought in with the mackerel at Lowestoft on October 12. The saury-pike (*Scombresox saurus*) has habits similar to the gar-pike, but occurs only occasionally, apparently not every year. Van Beneden states that he saw a shoal swim ashore near Ostend. The anchovy fishery in the Zuyder Zee and the Schelde takes place principally in June and July, although young specimens are found there for some time afterwards. They appear to depart entirely before the end of October.

---

* *Mémoires de l'Acad. Roy. de Belgique.* Tom. *XXXVIII.*

There can be little doubt, I think, that the annual incursion of these migratory fishes into the North Sea along the continental coast depends primarily on temperature. In the regions we are considering the depth is less than 20 fathoms, and there can be little question of difference between bottom and surface temperature. In February, which is the month in which the water is coldest, as we have seen the west side of the North Sea is at 6°, the east side, east of the Texel, 4° to 5°. We may consider that this is cold enough to drive out mackerel and the other species mentioned. At this time the limit of 9° C. lies to the west of the western entrance of the Channel. Mackerel in January and February are caught in the western part of the Channel as far east as Start Point. In May the limit of 8° has advanced eastwards and runs across the North Sea from the southern part of Denmark to the Firth of Forth. In August temperatures above 13° prevail over the whole of the North Sea, and in November we find the cold again advancing from north to south and from east to west.

These surface temperatures do not, however, explain the absence of the fish in question from the coast of Britain in summer. The restriction of the fish to the continental coast may be due to two causes: firstly, a movement of water in that direction; secondly, the extension of the deeper portion of the North Sea along the east coast of Britain. The salinity of the water has little to do with the matter. We have seen that in 1894 the oceanic water was more extended in February than at any other time of the year. Concerning the question of an inflow of water from the Straits of Dover, this distribution of surface salinities does not indicate that it is greater in summer than in winter. The report of an expedition for physical investigation, to which no reference has yet been made, namely, that of the *Pomerania* in 1872, does mention that the outflow of the warmer water from the southern area of the North Sea was traced as a current which flowed along the coasts of Schleswig-Holstein and Jutland to the Skagerack. This was in summer, but it seems to me that the surface salinities indicate that this current is due rather to the greater outflow of fresh water from the continental rivers, than to a greater flow of salt water from the Straits of Dover. At any rate, so far as I understand it, the physical evidence does not show that there is an inflow of Channel or Atlantic water corresponding to the immigration of southern aperticolous fish, while the higher temperature which does correspond to that immigration appears to be caused by the warming of the land and shallow water by the summer sun.

On the other hand, the *Pomerania* observations actually prove that in the deeper north-western depression the bottom water was frequently below 8° C., and that the passage of this cold water southwards was arrested by the Dogger Bank. I think it would be more correct to say that the boundary of this cold water to the south and east is the 25 fathom line. It is reasonable to infer that although the temperature at the actual surface in summer on the north-east coast of England is by no means low enough to account for the absence of mackerel, anchovy, etc., yet the influence of the cold water below is sufficient to restrict these southern species to the region south and east of the 25 fathom line.

We proceed next to the consideration of the southern species of fundicolous or bottom fishes in the Heligoland Bight and southern area of the North Sea. The list of these is rather a long one. The commonest of them are: *Rhombus maximus,* the Turbot; *Rhombus laevis,* the Brill; *Solea vulgaris,* the Sole; *Solea lutea,* the Solenette; *Trigla gurnardus,* the Grey Gurnard; *Trachinus draco,* the Greater Weever; *Trachinus vipera,* the Lesser Weever.

Less abundant are: *Trigla hirundo,* the Tub or Latchet; *Trigla cuculus,* the Red Gurnard; *Mullus barbatus,* the Red Mullet; *Callionymus lyra,* the Dragonet; *Arnoglossus laterna,* the Scaldfish; *Galeus vulgaris,* the Tope.

Heincke does not mention *Trachinus vipera* among the fishes of Heligoland. In the voyage of the *John Bull* off Amrum in June, I saw nothing of either species of weever, but both were very common on the Brown Ridges off the Dutch coast in September.

Heincke believes *Trigla cuculus* to be absent, but I saw specimens, identified with certainty, taken frequently in the trawl in my voyages both north of Heligoland and on the Brown Ridges.

As occasional immigrants the following species occur: *Labrax lupus,* the Bass; *Zeus faber,* the John Dory: *Gadus luscus,* the Pout or Bib; *Motella tricirrata,* the Three-Bearded Rockling; *Conger vulgaris,* the Conger; *Mustelus vulgaris,* the Smooth Hound; *Scyllium canicula,* the Small Spotted Dog-fish; *Trygon pastinaca,* the Sting Ray.

To the fundicolous forms may be added *Amphioxus lanceolatus,* which burrows in the sea-bottom, and is common near the Horn Reef.

How far the movements of these fundicolous species are influenced by the seasons we have very little evidence to show.

I think that it will be found that the occasional immigrants are usually taken in the area in summer, *i.e.*, during the period when the water is warm. I obtained a specimen of *Mustelus vulgaris* off Lowestoft on September 18th. The grey gurnard is not such a distinctly southern form as the latchet, nor is the red, *Trigla cuculus*. On board the steam-trawler *Lucania*, to the south of the Horn Reef in May, no latchets were taken, while northern forms, such as haddock, were abundant, and one halibut was taken. Grey gurnard were plentiful. Latchets were plentiful off Amrum in June, and on the Brown Ridges in September.

It will be found that the abundance of these forms in the Heligoland Bight is in proportion to the degree of their restriction to a southern habitat. The turbot, brill, and sole are fairly common along the north-east coast of England, while turbot and brill extend along the east coast of Scotland, accompanied by *Trigla cuculus*. As for the weevers, I do not think they are rightly said by Heincke to be common in the neighbourhood of Heligoland, as I did not meet with them there, nor at Grimsby, and although McIntosh records them as not uncommon at St. Andrew's, this may mean merely that a few specimens are seen every year. They were certainly abundant on the Brown Ridges in September.

It is well known that in hard winters soles are caught by the trawlers principally in the deeper depressions in the North Sea, especially in the Great Silver Pit south of the Dogger Bank. The latter is an isolated depression, and being cut off from the influence of the water in the deep valley along the north-east coast of Britain, probably contains warmer water than that valley in winter. The physical condition of such depressions in winter does not appear to have been examined, but the fact that soles collect in the Great Silver Pit in winter indicates that the species we are considering are affected by the fall in the temperature of the shallow eastern and southern waters in the coldest months of the year. At present I have no further knowledge of the relative abundance of the southern fundicolous species in the southern area and the Heligoland Bight from December to April.

The third class of southern species in the same region comprises the littoral species, which live principally among the sea-weeds of the littoral zones, and belong chiefly to the families of wrasses, pipe-fishes, gobies, etc. The commonest of these at Heligoland are: *Gobius minutus*, the Sand Goby; *Nerophis aequoreus*, the Snake Pipe-fish; *Ctenolabrus rupestris*, the Goldsinny. Less abundant are: *Syngnathus acus*, the

Common Pipe-fish; *Siphonostoma typhle*, the Broad-nosed Pipe-fish; and still rarer, *Labrus mixtus*, the Striped Wrasse. To these may be added *Mugil chelo*, the Thick-lipped Grey Mullet, which haunts the shore, but is an active wandering fish, not restricted in its movements like the others.

Heincke does not mention *Labrus maculatus*, the Spotted Wrasse, which, having a much more extended range than *Labrus mixtus*, is more likely to occur at Heligoland than the latter. Possibly this is a mistake, and *maculatus* should be substituted for *mixtus* in the above list. *Labrus maculatus* has certainly been taken at Yarmouth and Lowestoft, and occurs all along the east coast of Britain, while *mixtus* has scarcely ever been taken there.

It is not likely that any of these species, except the grey mullet, make long journeys at different seasons; they are in all probability resident where they are found in the region considered. They are southern species, which are able to bear the winter cold: Heincke states that they are driven in the cold months of the year from the inter-tidal zone into somewhat deeper water.

My conclusions concerning southern species entering the North Sea from the south, are as follows:—

(1) The area in which the more characteristic southern species, such as mackerel and *Trigla hirundo* are found, is bounded by a line drawn from the north coast of Norfolk in a north-easterly direction to the 20 fathom line, and following the latter limit to the Horn Reef.

(2) Certain southern aperticolous species visit this area only in summer, from May to October, and certain fundicolous species are found there at the same time, but how far the latter are absent in winter is not known.

(3) The immigration of these southern forms at this period of the year appears to be determined by the higher temperature due to the season, not by an inflow of water taking place only at that season. The uniform shallowness of the water is, however, an important factor, on the one hand causing a great difference between summer and winter temperatures, and, on the other, protecting the area in summer from the influence of the cold water in the deeper part of the North Sea, to the north and west.

SOUTHERN SPECIES ENTERING AT THE NORTH.

We next proceed to study the distribution and migrations of southern species in the northern part of the North Sea. In a previous part of this paper, I have already given a list of 18 species of southern forms, which according to Möbius and Heincke are occasionally taken in the

Western Baltic. But it will be more instructive now to take the species of the southern area in the divisions already distinguished, and note which occur in the Western Baltic and which do not, and what others occur in addition. This analysis has been made by Heincke. Of the aperticolous southern species of the southern area of the North Sea, all occur also in the Western Baltic. The mackerel, scad, and gar-fish occur in some numbers, and are classed by Möbius and Heincke as constant rarer residents, but are really summer immigrants making their appearance in May, and absent after October or November. The hake is a rare visitor, and has only been occasionally taken on the east coast of Schleswig-Holstein in November and December. The tunny and anchovy are also but occasional immigrants, which have been occasionally taken in autumn.

Of fundicolous forms, the following, according to Heincke, do not occur in the Western Baltic: *Zeus faber*, the Dory; *Callionymus lyra*, the Dragonet; *Gadus luscus*, the Pout; *Motella tricirrata*, the Three-bearded Rockling: *Solea lutea*, the Solenette; *Arnoglossus laterna*, the Scald-fish; *Galeus vulgaris*, the Tope; *Mustelus vulgaris*, the Smooth Hound; *Scyllium canicula*, the Small Spotted Dog-fish; *Amphioxus lanceolatus*, the Lancelet.

All these species have, however, been found in more or less abundance on the west and south coasts of Norway, with the exception of two, *Solea lutea*, and *Mustelus vulgaris*. The latter has been taken at the Shetlands and Orkneys. Of littoral species only two, *Nerophis aequoreus* and *Labrus mixtus*, are stated by Heincke to occur at Heligoland and not in the Western Baltic, but these again are fairly common on the south and west coasts of Norway, as far to the north as Tromsö.

On the other hand, the following southern species occur in the Western Baltic, which are not found in the Heligoland Bight or the southern part of the North Sea:—

APERTICOLOUS: *Sciaena aquila; Xiphias gladius; Orthagoriscus mola; Carcharias glaucus.*

FUNDICOLOUS: *Brama Rayi* (deep sea); *Gadus minutus; Raja fullonica.*

LITTORAL: *Gobius niger; Labrus maculatus; Crenilabrus melops; Nerophis ophidion.*

In addition to these a large number of southern species have been taken more or less frequently on the west coast of Norway. Of pelagic or aperticolous forms, Collett (*Norges Fiske*, 1875) gives *Lampris luna; Antennarius marmoratus; Argyropelecus Olfersii; Exocoetus volitans; Alopecias vulpes; Scopelus caninianus; Scombresox saurus.*

These southern aperticolous forms found on the coast of Norway, and not in the southern part of the North Sea, are oceanic species which live in the warmer parts of the Atlantic far from the coasts. The warm surface drift of the Gulf Stream carries them occasionally to the south-west coast of Norway, as also to the west coasts of the British Islands, but they do not penetrate through the English Channel and are, therefore, not seen in the southern part of the North Sea. They appear to be usually taken on the Norwegian coast in summer.

Certain deep-sea species extend from the Mediterranean to the coast of Norway, such as *Argentina sphyraena*, but most of these have a very wide range, and need not be considered in relation to the present subject.

The southern character of the fish found on the south-west coast of Norway is strikingly exhibited by the numerous species of *Scombridae*, *Percidae*, *Sparidae*, and *Labridae*, which are found there. Besides those which have been mentioned as occurring in the Western Baltic, we have of shallow-water forms:—*Pagellus centrodontus*; *Cantharus lineatus*; *Polyprion cernium*; *Acantholabrus exoletus*; *Acantholabrus couchii*; *Pristiurus melanostomus*; *Spinax niger* (deep sea); *Lamna cornubica*: *Nerophis lumbriciformis*.

In considering the relation of the occurrence of these southern forms on the south-west coast of Norway to physical conditions, we have to remember that a narrow channel over 200 fathoms in depth runs along that coast at no great distance from the shore, and that even the 100 fathom line does not go further north than the latitude of the north coast of Scotland. The warm Gulf Stream is only a surface layer, and beneath it is colder water. A large number of the southern species have only been occasionally taken on the Norwegian coast, and then chiefly in summer and autumn. They are probably to be regarded as isolated stragglers, which have been partly tempted onwards by the warmth of the water, partly carried by the surface drift. More detailed information concerning the permanence or periodicity of the occurrence of these species on this coast is required. The information available in Smith's recent edition of Fries and Ekström's *Scandinavian Fishes*, I have not yet had time to study thoroughly, as it is only given in separate statements under each species. It would appear, however, that a considerable number of littoral southern species are resident all the year, and it is to be noted that the surface temperature on the coast of Norway, to the north of 60° N. L., does not fall in February below 6°, while in the Heligoland Bight it is between 4° and 5° C. in that month.

It has been shown by the physical observations previously reviewed that in summer a strong surface outflow from the Baltic northwards along the Norwegian coast takes place, while in winter this is entirely cut off. This water flowing out in summer is at a high temperature, being warmed by the sun. It is therefore as warm as the Gulf Stream surface water from the Atlantic, and it seems to me that this fact is the chief condition determining the annual arrival of mackerel, gar-fish, scad, and anchovy on the south-west coast of Norway, and at the entrance of the Baltic.

The southern forms which have been mentioned occur also to some extent along the east coast of Scotland, but more commonly towards the north. It is therefore evident that they come round the northern end of Britain, and travel southwards. Here, again, detailed information as to the duration of their stay is at present deficient. It is stated that mackerel do not appear at the Orkneys till July, and in the Moray Firth are most abundant in August. The gar-fish, skip-jack, scad, and anchovy are all also recorded as occurring in the Moray Firth and on the east coast of Scotland, the three former as far south as St. Andrew's and the Firth of Forth. Others of the southern species which have been mentioned also are taken as isolated individuals, or in small numbers, as far south as St. Andrew's, and only in summer and autumn. *Trigla hirundo,* for instance, has been once taken at St. Andrew's, while *Pagellus centrodontus* is said to be not uncommon there. *Zeus faber,* the dory, is rare in that locality. *Labrus maculatus* occurs, and the only other wrasse is *Crenilabrus melops,* which is rare. The southern forms are scarcest or altogether absent between the Firth of Forth and the Wash.

Distribution of Northern Species.

The northern species, that is, species whose range extends beyond the Arctic circle but not into the Mediterranean, which occur in the Western Baltic, are chiefly littoral species, or fundicolous species, inhabiting moderate depths. The herring is the chief exception, being almost the only aperticolous species in the list. The species, as given by Möbius and Heincke, are: *Cottus scorpius, Cyclopterus lumpus, Centronotus gunnellus, Zoarces viviparus, Spinachia vulgaris, Gadus morrhua, Gadus aeglefinus, Gadus merlangus, Ammodytes tobianus, Pleuronectes platessa, Pleuronectes limanda, Pleuronectes microcephalus, Hippoglossoides limandoides, Clupea harengus.* Less abundant are: *Cottis bubalis, Agonus cataphractus, Liparis vulgaris, Gadus pollachius, Lota molva, Motella cimbria.* The occasional immigrants are: *Anarrhichas lupus, Gadus virens, Pleuronectes cynoglossus, Hippoglossus vulgaris, Liparis Montagui, Stichaeus islandicus (Lumpenus lampetraeformis), Brosmius brosme, Raia radiata.*

As we have seen, Pettersson points out that these northern immigrants are taken in the Baltic early in the year, from February to April, at which season the Baltic outflow has ceased, the force of the

Gulf Stream is diminished, and an influx of cold water 4° to 5° C. takes place into the Baltic, from the north along the Norwegian coast.

Five of these occasional immigrants are absent from the Heligoland region, namely, *Liparis Montagui*, *Stichaeus islandicus*, *Brosmius brosme*, *Pleuronectes cynoglossus*, and *Raia radiata.* These are also wanting in the southern shallower part of the North Sea, that is to say, south of the 20 fathom line, except *Liparis Montagui*, which, according to Day, occurs at the mouth of the Thames and on the south coast of England. These five are the most especially northern of the above list, and are true Arctic species. *Liparis Montagui* is common along the east coast of Scotland and north-east coast of England. Of *Stichaeus islandicus*, only one or two specimens have been taken occasionally in the north-western part of the North Sea, once in 40 fathoms off St. Abb's Head, once in February, 1894, off the mouth of the Firth of Forth, and two specimens in July, 1892, 240 miles E. ½ N. from Spurn Head. *Brosmius brosme*, the tusk or torsk, is abundant from Spitzbergen to the Shetlands, but further south becomes scarcer: it has only been occasionally taken off the Yorkshire coast. *Pleuronectes cynoglossus*, the witch, is abundant on the Great Fisher Bank, and may be said to be limited in the North Sea by the 30 fathom line. *Raia radiata* has a similar distribution, not being found south of Yorkshire.

Two species found in the Heligoland region have not been taken in the Baltic, namely, *Carelophus ascanii*, of the blenny family, and the rockling, *Motella mustela.* The former is common on the north-western coast of Norway, and occurs rarely on the east coast of Britain as far south as Yorkshire. *Motella mustela* extends southwards throughout the southern area of the North Sea, and occurs also on the south coast of England.

The other three occasional immigrants into the Western Baltic, namely, the cat-fish, the coal-fish, and the halibut, occur along the east coast of Britain as far to the south as the 30 fathom line, but not south of it.

Hippoglossoides limandoides, the long rough dab, is resident in the Baltic, and also in the north part of the North Sea, north of the 30 fathom line, but is absent from the Heligoland region, and from the shallow southern area.

The other species mentioned in the above list, although not entirely absent from the southern area and the eastern slope of the North Sea, become much scarcer there, as will be seen from the observations in these areas recorded in the two previous numbers of this Journal. The lemon dab *(Pleuronectes microcephalus)* is found more plentifully along the English coast in the southern area, *i.e.*, along the line of deeper water. *Lepidorhombus megastoma*, the megrim, is a northern form, not mentioned in the above list because not occurring in the Baltic. It is common in the northern part of the North Sea, in the deeper water, and also at Iceland, and at depths over 30 fathoms on the south-west coast of England.

In the northern region the species most abundant in individuals are haddocks, whiting, cod, plaice, dabs, lemon dabs, witches, long rough dabs, megrims, cat-fishes, ling, while on the southern ground the only northern species which are abundant are whiting, plaice, and dabs.

In this discussion I have omitted all mention of a number of species, such as *Raia clavata*, the thornback ray; *Raia batis*, the skate; *Lophius piscatorius*, the angler; which are classed by Heincke and Möbius as of indefinite distribution, because they either extend both to the Arctic Ocean and the Mediterranean, or to neither.

In the further consideration of the distribution of northern species, three subjects may be taken separately: (1) the general physical conditions, (2) the migrations of the herring, (3) the difference in the size of fish of the same species in different parts of its habitat.

(1) *The general physical conditions.* In general terms, the physical fact which determines the distribution of northern species of fish in the North Sea, is that deep water in open communication with the Arctic Ocean extends along the east coast of Britain towards the coast of Norfolk. If we look at the contour lines of the sea-bottom, we see that the 100 fathom line passes round the north of the Shetlands and bends round to the south, parallel to the Norwegian coast and at no great distance from it. The 50 fathom line passes down the east side of the Shetlands, Orkneys, and the east coast of Britain to the latitude of the Farn Islands, and runs north again along the west side of the Great Fisher Bank, to the edge of the Norwegian depression. The 40 fathom line runs further south off the east coast of England, and to the west of the Dogger Bank and Great Fisher Bank. The 30 fathom line runs outside the Dogger Bank, and the whole of the Fisher Bank is more than 30 fathoms in depth. But the 20 fathom line isolates the Dogger Bank, and leaves a valley between it and the slope of the mainland. To the south of this valley the 20 fathom line runs across the North Sea from Flamborough Head to the continental slope.

Apart from movement of the water, this depression must contain at the bottom water which is continuous with the cold bottom water of the Arctic Ocean, and which cannot be much affected or raised in temperature by the warm current of the Gulf Stream, both because that is a current of surface water, and because it flows past the north of Britain to the Norwegian coast. We see thus that the roads of the northern forms and southern forms actually cross one another to the east of the Shetlands and Orkneys, the southern species travelling in the warm surface water of the Atlantic to the south-west coast of Norway, the northern species moving at the bottom down the western side of the North Sea.

The observations of the *Pomerania* expedition previously mentioned, show that in summer, in the deep depression, the temperature at the bottom was not higher than 8° C., while at the surface it was 12° to 14° C. At the western side of the southern area the temperature at the bottom was somewhat lower than at the surface, but not on the eastern side. This is attributed to an inflow of cold water from the north. It seems to me that it is with regard to this question of the flow of the cold bottom water at different times of the year, that further information from the physicists is most required. We know that northern forms, such as haddock and lemon dabs, extend down the east coast of England as far as the Thames, in greater numbers than on the continental side, and we know that there are isolated depressions over 20 fathoms in depth along this side, which are wanting on the continental side. But it would be interesting to know further to what extent the cold water makes its way southward beyond the latitude of the Wash, and what is the cause of its movement?

Reference has already been made to Dickson's account of the entrance of oceanic water down the east coast of Britain from the north, and his opinion that the important property of this water is, that it contains more oxygen than the bottom water of the deeper part of the North Sea, which it replaces. In his interpretation of the observations, Dickson has laid chief stress on the introduction of *Atlantic* water into the west side of the North Sea at the bottom, and says little of the temperature of the introduced water. Apparently the reason of this is, that the Atlantic water was originally surface water, and was presumably saturated with oxygen. Now, the question of the oxygen in the bottom water introduced, or in that which it displaces, has not been directly investigated. It seems to me that it is very desirable that Mr. Dickson and the other physicists who are studying the phenomena in question, should consider the movements of the water in relation to the contrasted distribution of northern and southern fish, of which I have in this paper attempted to trace the main features. The herring is a northern species, abundant in the Norwegian Sea, and its incursions into the North Sea must, I think, depend, like the presence of the other northern species characteristic of the north-western part of that sea, on the introduction not of Atlantic water, but of cold water from the Norwegian Sea. It seems to me the question is one rather of temperature than of oxygen. In Dickson's conclusions it is noteworthy that the introduced water is a mixture of Atlantic water and water from the Norwegian Sea, and to me the latter constituent and its low temperature appear to be the more important factors. In any case it is important that Dickson concludes from his observations that cold bottom water does flow from the north down the north-western depression of the North Sea, and this fact corresponds to the prevalence of northern species of fish in that depression and the east coast of Britain.

(2) *The migrations of the herring.* Turning more particularly to this difficult subject, I cannot profess, with the data at present available, to give a complete explanation of these migrations. I propose merely to point out some of the more obvious relations, in the hope that my remarks may be of some use in directing attention to the conditions which have to be investigated.

On the east coast of Scotland, it appears at first sight that the summer herring arrive and are present when the water is warmest. In the northern part, for instance in the Moray Firth, the chief fishing is in July and August. Further south it gets later, taking place in August and September, while at Lowestoft it lasts from October to the beginning of December. There is a mackerel fishing at Lowestoft in September and October, so that during October, as I know from personal observation, both mackerel and herrings are being landed in numbers at the same time. But it must be remembered that the mackerel are going away to the south, and herrings are arriving from the north, and also that mackerel usually swim near the surface, and herring near the bottom, or at some distance below the surface. It is probable that at this time when the herrings visit the neighbourhood of the Norfolk and Suffolk coasts, the bottom water is colder than it has been during the preceding summer, in consequence of the inflow of bottom water from the north. This does not explain why the herrings are absent in January, February, and March. But the herrings come to spawn, and there is some evidence that they retire northwards into deep water to feed. All that I would suggest is, that we do not know that the bottom water, where the summer herring spawn, is at its warmest when the spawning takes place off Lowestoft, although, according to Dickson, the mixed Atlantic water which makes its way down the east coast of Scotland in summer is warmer than the water it displaces. The warmth of the inflowing water, however, is not very great, its temperature is not above 9° C. We have seen that, according to the observations of the *Pomerania*, the temperature at the bottom in the northern part of the North Sea in summer is frequently below 8° C., and we do not know what the winter temperature is. The hypothesis that the arrival of herrings is connected with a greater supply of oxygen, seems to be inconsistent with the fact that there is at all times of the year such an abundance of bottom fish (haddock, plaice, cod, etc.) in the places where the summer herring fishery is carried on.

We have seen that Pettersson traces a distinct connection between the herring fishery in the Skagerack and Cattegat, and the inflow of coast water. But there appear to be two periods of inflow, one from the south of warm water 15° C. to 16° C. in temperature in August and September, and one from the north of cold water 4° to 5° C. in January, February, and March. Herring fishery is associated with both of these, but principally, it would appear, with the northern water, which contained northern forms of plankton. It is well known that there are winter spawning herring in various localities, which must be considered to be races quite independent of the summer spawners. With regard to the relation of the fish to temperature, it is suggestive that on the south-west coast of England, in the neighbourhood of Plymouth, there are no herrings in summer or autumn, but only from about the end of November till the end of February, that is at the time when the water is coldest.

Dr. John Murray considers that there is evidence that the herrings of Loch Fyne and the Firth of Clyde reside there permanently, and do not merely make periodical visits, and believes that they feed chiefly in the deep depressions near the bottom. Whether these are the herrings which spawn on the Ballantrae Banks in early spring, we cannot definitely decide at present. But enough has been said to show that the introduction of Atlantic water with a greater supply of oxygen is not a sufficient explanation of the annual migration of summer herrings into the North Sea, and that probably some important and interesting discoveries have yet to be made concerning the relation between the food, breeding, and movements of herrings, and the temperature of the water in which they are found at different seasons.

(3) *Different sizes of fish of the same species at different parts of its habitat.* Mr. Holt's observations, together with my own, as published in previous numbers of this Journal, have shown the different sizes of plaice in (1) the northern and western part of the North Sea (2), on the south coast of Iceland (3), in the southern shallow part of the North Sea and in the English Channel. In the two latter cases the difference has been precisely exhibited in the lengths of the smallest mature and largest immature specimens. This is probably the best method of testing the matter, for the average size of mature specimens as a standard is liable to the objection that it depends on the extent to which older and larger fish are captured. Mr. Holt's observations in the Journal, and Petersen's* in the Annual Report of the Danish Biological Station, refer to small races of plaice in the Baltic. There are three points to be taken into consideration in relation to these

---

* Dr. C. G. Joh. Petersen, the Danish biologist, is not to be confounded with Prof. Pettersson, the Swedish hydrographer.

size-varieties or geographical races: (1) that their occurrence in the plaice is only one instance among a number, several other northern species, *e.g.*, the Greenland bullhead, *Cottus groenlandicus,* and the so-called Norway haddock, *Sebastes norvegicus,* being very much larger on more northern coasts than on British coasts or on the south coast of Norway; (2) the question whether definite structural peculiarities are present, as well as mere size, to distinguish the geographical forms from one another; (3) the question whether the differences are hereditary, each race breeding and transmitting its peculiarities independently, or whether the fish are the offspring of parents from other areas, and owe their peculiarities merely to the conditions under which they have lived and grown.

With regard to the first point, we cannot say that the existence of geographical races differing in size is peculiar to northern forms, although it is to these that my attention has been principally directed. It is probable enough that any wide-spread species may be found to show the same state of things. At a certain part of its habitat it appears that a species attains its greatest development, because there the conditions, whatever they may be, are most favourable to it, and at regions lying near the limits of its range it is less favourably circumstanced, and is found in smaller numbers and of smaller size. In Greenland it is stated that the short-spined bullhead attains to six feet in length, although it is the same species as the *Cottus scorpius* occurring on the east coast of Britain, where it never exceeds a length of fifteen inches. It is very difficult to decide what are the favourable and unfavourable conditions which cause the differences in size in such cases, and the investigation of these conditions would be both important and interesting. With regard to the plaice and other northern species, it might be supposed that a higher temperature was the chief unfavourable condition, and it may probably enough be one of them. We know that the water of the Channel is warmer than the bottom water of the northern part of the North Sea, and this higher temperature extends for great part of the year to the southern narrower area of the North Sea. But on the other hand, the Baltic, which contains plaice of small adult size, is colder, except perhaps in the height of summer, than the North Sea. Here it might be supposed that the lower salinity was an unfavourable condition, but this would not apply to the English Channel. It is possible that the amount of available food, the extent of suitable ground, and the competition of other species, have more influence on the size and general development of a particular species than purely physical conditions such as salinity and temperature.

With regard to the second point, it is found in many cases that minute structural peculiarities do co-exist in geographical races together with limits of size. Such races, therefore, must be regarded as incipient species; they only differ from species in the minuteness of the structural peculiarities and in the absence of definite limits between one race and another, a continuous transition from one to the other being observed in individuals and in intermediate areas. The study of such geographical varieties is therefore philosophically important, since in these cases we have actually the origin of species before our eyes.

Mr. Holt has previously written in this Journal concerning the ciliation of the scales in the males of the dwarf variety of plaice in the Baltic, and mentioned that these plaice have been stated to have a smaller number of dorsal and ventral fin-rays. Dr. Heincke had suggested that the Heligoland plaice were smaller than those of the western side of the North Sea, and probably formed a local variety. Dr. Georg Duncker, at Heincke's request, has investigated,* by the method applied by the latter to races of the herring, the distinguishing characters of local varieties of the plaice. He examined separately specimens from Greifswald, Kiel, the Cattegat, all localities in the Baltic, and from the neighbourhood of Heligoland. It appears from Duncker's results that ciliation restricted to the middle rays of the dorsal and oval fins is more common than a greater extension of the condition. It was more developed in specimens from Kiel and the neighbourhood than in those from the Cattegat, and in specimens from Heligoland was found on the body in two males out of 35, on the fins alone in 18 out of 35. But unfortunately no examination was made of specimens from other parts of the North Sea, and therefore it remains an open question whether the plaice of the Heligoland Bight have the special characters of a local race. Only a small number of specimens altogether were examined by Duncker. It will be remembered that my own examination of the size of mature specimens went to prove that the plaice of the Heligoland region were not smaller at maturity than those of the north-western part of the North Sea. The examination of specimens from the different regions of the North Sea, for the purpose of ascertaining whether constant structural differences can be found distinguishing the local forms, is yet to be carried out.

With regard to the third point, whether the peculiarities of local races are hereditary, or are acquired by the individual in consequence of the conditions under which it has lived and grown, to decide upon this, it would be necessary to know in each case how far interchange of individuals takes place between different areas, or whether the individuals of a region are the offspring of parents which lived in the same region. At present it is difficult to give answers to these questions. The English Channel is so extensive that we can confidently conclude that the plaice found there are the offspring of parents that also lived there. But we cannot be certain that the eggs of plaice which spawn between Lowestoft and the Dutch coast are not carried by the currents to some distant region, most probably to the Heligoland Bight, where they would develop into plaice of larger size at maturity. Similarly we cannot be certain that young plaice on the German coast near Heligoland are the offspring of parents which themselves grew up on that coast. To obtain evidence on these matters we must trace with more certainty the movements of the adult fish, and the course which the eggs are compelled to take by the currents. Something has been done in this way by the hydrographers, and by Dr. Fulton in his experiments with floating bottles, and the results indicate that the plaice of the Heligoland Bight are largely derived from spawn shed in the central part of the North Sea. In the Western Baltic the plaice have marked characteristics, distinguishing them even from those of the Cattegat, especially in the small size at which they are mature. Yet according to Petersen, young plaice, in the first summer after their development from the egg, are not found in the Baltic east of Zealand, Moen, and Falster at all, but enter it from the Cattegat when a year old. At the same time, Petersen finds indications that the mature fish in the Baltic emigrate through the Great Belt and spawn in the Cattegat, so that the dwarf plaice of the Baltic, with all their peculiarities, might be the offspring of parents which lived in the Baltic.

---

* Variation und Verwandtschaft von *Pleuronectes flesus L.* und *Pl. platessa L.*: *Wissenschaftliche Meeresuntersuchungen. Neue Folge, Erster Band, Heft 2, 1896.* (See this Journal, vol. iv. p. 293.)

Note on a Specimen of Echinorhinus spinosus.

By

F. B. Stead, B.A.

A specimen of this somewhat uncommon shark was recently brought to the Laboratory by some fishermen. The following notes on it may be of interest. The fish was taken with a long line baited with mackerel, for conger. It was captured forty miles south of the Mewstone, at a depth of about forty-five fathoms. The specimen was a female, and measured 6 feet 6 inches from the end of the snout to the tip of the tail. The following are the principal other measurements: snout to anterior edge of first dorsal fin, 46 inches; snout to anterior edge of pectoral, 20 inches; the interval between the anterior edge of the pectoral and the pelvic fin was 26 inches. The first dorsal, which was small, was thus situated immediately above the pelvic. The second dorsal, which was smaller than the first, was situated as nearly as possible midway between the first dorsal and the commencement of the caudal fin. The measurements so far tally with Day's description of the species.

Attention may, however, be drawn to the measurements which follow in connection with the following statement in Day: "Ventral (fin) . . . commences mid-way between the front gill opening and the end of the caudal fin in elongated forms: or anterior end of the snout and middle of the caudal fin, as observed in the Plymouth and Aberdeen stouter specimens." (Day's *British Fishes*, vol. ii. p. 323.)

In my specimen the distance from the front gill opening to the anterior edge of the ventral was 30 inches: thence to the end of the caudal was 33 inches. On the other hand, the distance of the anterior edge of the ventral to the middle of the caudal was 26 inches, and to the end of the snout was 44½ inches.

It will be seen that my specimen corresponds to one of the "elongated forms," and not to the "stouter specimens," said to have been observed in Plymouth. Considering the relatively small number of specimens of this shark which have been captured and measured, the distinction between the elongated and stouter forms is perhaps hardly justified, and the measurements above recorded show that Plymouth specimens do not invariably belong to the latter class.

In other respects my notes as to the external features of the fish agree with Day's description.

The specimen was sent to the Museum of Zoology at the University of Cambridge, and I am indebted to Mr. S. F. Harmer for the following further facts in connection with it:

The ovaries were undeveloped: there were no large ovarian eggs, and the oviducts were quite small.

It should be noticed in this connection that the specimen was probably not full-grown. Day speaks of a female 9 feet long, containing 17 eggs, as having been taken off the Eddystone, and mentions a male 6 feet 2 inches long "having two large lobes of milt."

In various parts of the alimentary canal specimens were found of the parasite *Distomum insigne.* Several of these were attached to the roof of the pharynx; two were in the stomach, and appeared to be partially digested; one was in the small intestine, and several among the turns of the spiral valve. The alimentary canal contained nothing else except some glairy material and a few Isopods belonging to the species *Conilera cylindracea* (Montagu). One of these was in the stomach, and *alive,* though very sluggish; the others were in the large intestine, in the folds of the spiral valve, and appeared to be partially digested. There was nothing else recognisable in the alimentary canal.

In some of the specimens referred to by Day, it is stated that dog-fishes were found in their stomachs, and in one specimen there were no fish, but remains of Crustacea. Day further quotes a suggestion made by Mr. Cornish, that there are two permanent varieties of this shark—"one a ground-shark: the other a round or swimming." I have not been able to find the evidence on which this suggestion was based.

How do Starfishes open Oysters?*

By

Dr. Paulus Schiemenz.

MANY inhabitants of the sea know as well as men do that oysters are good to eat, and the destruction which they suffer on this account can scarcely be less than that brought about by human agency. Starfishes especially extirpate them in great numbers, and Möbius† maintains that they are the most pernicious enemies which the oyster possesses, although, on the other hand, people have not been wanting who held the destruction of oysters by starfishes to be a fable.‡

Collins|| calculates the damage done by these voracious robbers on the oyster beds of Connecticut alone for the years 1887, 1888, and 1889, at 463,600, 613,500, and 412,250 dollars, whilst that done in all other ways, by molluscs, mud, frost, etc., only represented a total of 39,200, 46,750, and 52,450 dollars.

In view of this enormous injury caused by starfishes to the oyster beds, it will be worth while to endeavour to obtain a clear idea of how a starfish really succeeds in eating an oyster. It is generally known that bivalve molluscs, and amongst them oysters, can close their shells so tightly against enemies that considerable force is necessary to open them, and the question arises, Is a starfish able to exert that force?

For the purposes of our discussion, we shall divide the starfishes which attack molluscs into two groups. Those of the first group have

---

* *Mittheilungen des Deutschen Seefischereivereins.* Bd. xii. No. 6, 1896. Translated from the German by E. J. ALLEN.

My thanks are due to Professor Dr. Henking, the general secretary of the German Sea Fisheries Association, both for permission to publish the translation of this article, and also for the loan of the blocks from which the figures are printed. E. J. A.

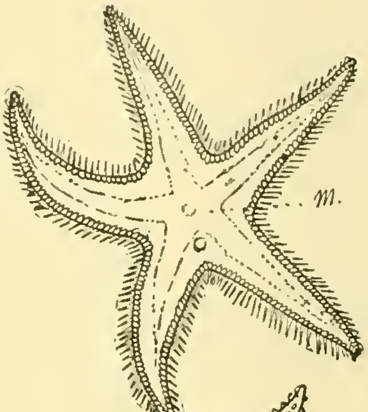
† MÖBIUS, K. "Ueber die Thiere der schleswig-holsteinischen Austerbänke, ihre physikalischen und biologischen Lebensverhältnisse." *Sitz.-Ber. Akad. Berlin.* 1893, pp. 67–92.

‡ FISCHER, P. "Faune conchyliogique marine du département de la Gironde." *Act. Soc. Linn. Bordeaux.* Tome 25, 1864, pp. 257–344.

|| COLLINS, J. W., "Notes on the oyster fishery of Connecticut." *Bull. U.S. Fish. Comm.*, vol ix. pp. 461–497, 1891.

conical shaped arms, increasing in width from the apex to the base, the united bases forming a more or less marked central body (*m*, Fig. 1*a*). *Astropecten aurantiacus*, which is common at Naples, may be taken as the representative of this group.* It lives in places where there is more or less deep sand, half buried in which it pursues its prey. The latter consists, for the most part, of bivalves and gasteropods which also bury in the sand, and the starfish forces them, by means of its flexible tube-feet, into its mouth, which is capable of a very remarkable degree of extension. The number and size of these molluscs which an *Astropecten* is capable of swallowing passes belief, and the naturalist who keeps one of them in confinement is often astonished to find, sooner or later, quite a collection of shells in the dish, all of which had been concealed in the huge stomach of the starfish. Hamann † counted at one time ten *Pecten*, six *Tellina*, several *Conus*, and five *Dentalium*.

Fig. 1*a*.



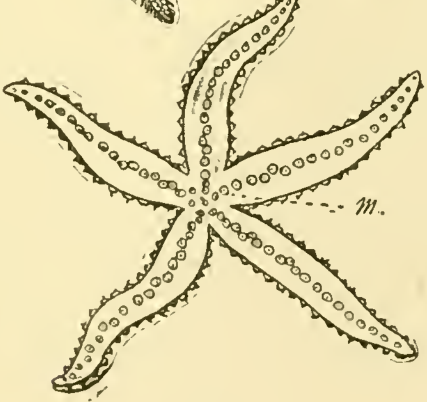


Fig. 1*b*.

In the second group of starfishes (Fig. 1*b*) the arms are far from being so conical in shape, but are more or less cylindrical; indeed in the immediate neighbourhood of the body they are somewhat smaller than a little further off, and hence no true body exists. The members of this group, *Asterias glacialis,* for example, prefer rocky places, or at least hard ground, to a sandy bottom. *Asterias* devours all animals which it can overpower, having, like *Astropecten,* a preference for bivalves (especially oysters) and gasteropods which lie free on the surface. On account of the small size of the disc, the mouth of *Asterias* is capable of very little enlargement, and it would never be able to swallow oysters, which are its favourite food. Moreover, oysters remain firmly fixed to the bottom, and gasteropods also can often hold on so fast that it appears impossible that they should be passed into the stomach through the mouth. *Asterias* therefore takes up exactly the same position as Mahomed. As the mountain did not come to the prophet, the prophet went to the mountain, and as *Asterias* cannot bring his prey into his stomach, he sends his stomach into his prey, that is to say, he throws his stomach out like a proboscis, either wrapping it around or forcing it within the shell of his victim, and in this way digests it entirely outside his own body. The throwing out of the stomach of the starfish has been often seen and described: amongst others by Eudes-Deslonchamps,* McAndrew, and Barrett (according to Bronn), Forbes,† Rymer Jones,‡ Bronn,‖ Eyton,§ Schmidt,¶ Hamann,** and Möbius.††

---

* *Astropecten irregularis* may be taken as the representative of this group in British seas. E. J. A.

† Hamann, O., *Beiträge zur Histologie der Echinodermen.* Heft 2. "Die Asteriden anatomisch und histologisch untersucht." Jena. G. Fischer, 8vo., 1885.

The following example will show how cleverly *Asterias* can force his stomach through openings which appear little adapted to the purpose. One would think that a sea-urchin, with its thick array of movable spines, would be safe from the attacks of a starfish; but this is really not the case, as I was myself able to observe, through the kindness of Sgr. Lo Bianco, the conservator at the Naples Zoological Station. A moderately large sea-urchin was attacked by two starfishes, one on either side. One of these had only just commenced the onslaught. It had thrown its stomach through the narrow space between the spines until it reached the skin of the urchin, which, together with the muscles that attach and move the spines, it devoured, so that the spines by degrees fell off. The second starfish had in this way, as one might say, already digested for itself a road through the spines, and with its stomach had reached the mouth of the urchin. Through this, in spite of the urchin's strong teeth, it had inserted its proboscis, and so sucked out its victim like an oyster.

---

[*] Eudes-Deslonchamps, "Notes sur l'Astérie commune." *Ann. Sci. Nat. Paris, Zool.* Tome 6, pp. 219–221, 1826.

[†] Forbes, Edw. *A History of British Starfishes and other animals of the class Echinodermata.* London 8vo., 1841.

[‡] Rymer Jones, *Frorieps N. Notiz.* Bd. 12. Nr. 288, 1839.

[‖] Bronn, H. G., *Klassen und Ordnungen des Thierreiches.* Bd. 2. Actinozoa, 1860.

[§] Eyton, T. C., "A history of the oyster and the oyster fisheries." *The Edinburgh Review,* vol. cxxvii. pp. 43–76, 1868.

[¶] In Brehm's *Thierleben. Grosse Ausgabe. Aufl.* 2. *Abth.* 4. Bd. 2. Leipzig, 1878.

[**] *Loc. cit.* [††] *Loc. cit.*

Astropecten and *Asterias* possess tube-feet of very different structure. Those of *Astropecten* are conical and quite pointed at the end, and seem extremely well adapted to boring in sand. Suckers at their ends are entirely wanting. Such enlargements would only be a hindrance when boring in sand. On the other hand, *Astropecten* has no need of suckers, for it does not climb steep walls; the animals which it preys upon all move so slowly that they could not escape by flight, and therefore do not require to be held fast; and thirdly, this starfish does not need to open its victims. With its feet it brings them into the capacious stomach, from which they cannot again escape. It has now only to quietly wait its time, until the animals, killed by suffocation, open their shells and allow the digestive juices to reach them.

In the case of *Asterias* the circumstances are quite different. The animal is a zealous climber, and by preference clings to perpendicular walls. If, like *Astropecten,* it possessed pointed tube-feet without suckers, it could not do this, but would fall down as *Astropecten* does when it attempts to climb in confinement. The animals which *Asterias* eats are some of them capable of relatively rapid locomotion, and therefore require to be held fast. Many of them, too, have the power of tightly closing their shells, and if the *Asterias* wishes to get at their soft bodies, the shell must first be opened. For clinging, as well as for opening shells, pointed feet would be quite useless. Feet, however, provided with powerful suckers, such as *Asterias* possesses, are well adapted to these uses.

There is, too, a difference between the ways in which the feet of *Astropecten* and *Asterias* move. Whilst *Asterias,* when the suckers have been loosened, curves the feet outwards, and so draws itself back, *Astropecten* curves them inwards. It is obvious that the latter mode of progression is much better adapted to a life buried in sand, such as *Astropecten* leads.

Different views have been expressed as to the manner in which *Asterias* and similar forms succeed in opening the shells of molluscs. At the present time it seems to be generally considered that this is accomplished by the secretion of a stupefying fluid, or poison. As we shall see, however, further on, this view is a complete mistake.

In what follows we shall consider (1) the possible methods by which the opening of the shell could be accomplished; (2) which of these is to be considered the most probable; and, finally (3), we shall endeavour to prove that this method is, in fact, adopted. There appear to be altogether six possible ways:—

1. *The starfish might take the molluscs by surprise.*—Bivalves, including the oyster, are generally very watchful. A small change of light, a shadow, a slight movement of the water, or any trifling disturbance,

immediately causes the closing of the shell. Such sensitiveness seems to preclude completely the idea of their being surprised by the starfish, for before the latter could reach, say, an oyster with its mouth or its everted stomach, it has already freely touched it with the feet on its long arms, and thereby given it sufficient warning. But even if the oyster allowed itself to be taken by surprise, as soon as ever it felt the stomach of the starfish on its soft parts, it would immediately close the shell, and the starfish would generally only be able to escape by tearing off its stomach. If anyone is not prepared to accept this without further proof in the case of the oyster, he has only to consider, say, a *Venus,* with its strong shell-margins, which, when closed, do not let the very finest crevice be seen, and which would at once crush such a soft body as the stomach of a starfish. According to Forbes, it is the belief of some oyster-fishermen that *Asterias* insinuates an arm into the oyster's gape in order to devour it. The oyster then closes, and the starfish is caught. To free itself again, and not die miserably of hunger, it elects to sacrifice an arm, and this is the reason why so many mutilated starfishes are found. This is a very pretty fable, but it is no more than a fable, for a starfish of moderate size does not insert an arm into a living oyster, for the simple reason that the gape of an oyster, when open, is much too small.

2. *The starfish might beset the oyster so long that it would be compelled, by hunger and want of air, to open.*—This supposition is made by the brothers De Montagué* and by Smiley.† To say nothing of the possibility that, in this case also, the stomach might easily be bitten off by a renewed closing of the shell, the duration of the attack would be a very long one, for it is well known that bivalves, and especially the oyster, can remain closed for a great length of time without air and nourishment. I fancy that during this long siege the starfish would get such a strong appetite itself that it would prefer to look around for more manageable prey. Moreover, the supposition stands in direct contradiction to an observation of my own, according to which from fifteen to twenty minutes is generally sufficient for the opening of a *Venus.*

3. *The starfish might hypnotise the molluscs.*—It is known that certain animals, if their bodies are placed in a quite unaccustomed attitude, are subject to a kind of hypnotism. According to Apgar,‡ if a *Unio,* for example, is seized quickly, and the shell firmly pressed, so that the

---

* De Montagué, frères, "Etudes pratique sur les ennemis et les maladies de l'huître dans le bassin d'Arcachon." *Act. Soc. Linn. Bordeaux,* vol. xxxii. (4 ser. Tome 2). 1879.

† Smiley, Chas. W., "Notes Upon Fish and the Fisheries." *Bull. U.S. Fish. Comm.,* vol. v. 1885. (From a statement by Capt. S. J. Martin.)

‡ Apgar, Austin C., "The Musk-rat and the Unio." *Journal Trenton Nat. Hist. Soc.,* vol. i. pp. 58, 59; also in *Zoologist* (3), vol. ii. pp. 425–426.

protruding foot is squeezed, after half to three-quarters of a minute it becomes paralysed, and can make no more use of the adductor muscles. Apgar believes that the musk-rat (*Fiber zibethicus*) takes advantage of this fact in order to get at the soft parts of the mussel. In the case of the oyster, however, anything of this kind does not apply, for it cannot be brought into an unaccustomed attitude, nor has it any foot to protrude and be squeezed. This could, however, happen with other bivalves which are not fixed and which possess a protruding foot; for, whilst being eaten, these are constantly placed by the starfish in a position quite the reverse of the normal one; namely, with the hinge below, and the gape above. I have tried experiments on the point with *Venus verrucosa,* but have failed to notice any hypnotic or paralytic effect. I have made a *Venus* stand for many hours on the hinge, and have afterwards found exactly the same resistance to forcible opening as at other times. Since, however, the starfish can effect the opening in from fifteen to twenty minutes, the possibility of hypnotic effect is precluded.

4. *The starfish might make an opening in the shell with the help of a boring apparatus or an acid.*—No boring apparatus is possessed by *Asterias*, and the holes which one often finds in oyster shells are due to gasteropods, and not to starfish, although they have sometimes, in error, been ascribed to the latter; *e.g.*, by Ball and Forbes. I have neither been able to find holes in the shell of a *Venus* which has been devoured, nor an acid reaction in the everted stomach. It is, however, a difficult thing in sea water, which is slightly alkaline, to demonstrate an acid with litmus paper; but when we recollect that the opening is effected in so short a time, the acid would necessarily require to be very strong, and should be capable of demonstration even under such unfavourable conditions. One does often find regular holes on the shell-margin of oysters which have been eaten, but, as we shall see presently, these are produced, not by boring, but by breaking.

We come now to the possibility—

5. *That the starfish pours a poison over, or, rather, within the shell of its victim, whereby the muscular force of the latter is enfeebled, and the shell opened.*—In itself this is not unlikely, and I was at first of opinion that this was, in fact, the method by which the opening was effected, for it is known that many animals maim their victims by poison, derived generally from the salivary glands, before devouring them. However, even this power would not be of much use to the starfish. As already mentioned, a *Venus*, for instance, squeezes its shell so tightly together that one could almost speak of its being hermetically closed. A poison poured over the shell could not penetrate, but would flow off without effect. In this case also it would be first necessary to

bore in the shell an opening through which the poison could be injected. However, as we have seen above (*cf.* 4), no such boring of the shell does, in fact, take place. The action of poison was assumed by Eudes-Deslonchamps, Forbes, Rymer Jones, Bronn, Eyton, O. Schmidt (in Brehm), and Smiley (following Captain Martin). Hamann attempts a detailed description of the process; but, for myself, I fail to see upon what logical grounds, from the presence of a slimy fluid and the opening of the bivalve, a proof for the secretion of poison can be derived. It is not even shown whether the slime comes from the starfish or from the bivalve, and it is a fact, which anybody can easily observe, that bivalves and gasteropods commence a copious secretion of slime if their soft parts are handled. I have, however, made experiments which demonstrate quite certainly that *Asterias* does not secrete a poison, or, rather, that a maiming of its victim by this means does not take place. A *Venus verrucosa* was offered to an *Asterias* which had fasted for about a week, and was greedily taken. Whilst the starfish was busy opening, or, rather, eating this *Venus*, a second one was offered it. This also was immediately taken and, for the time, held fast, its hunger, after the long abstinence, not being satisfied in a moment. When the first mollusc was finished, and its empty shell thrown away, the second was carried by the tube-feet to the mouth, and brought into the usual position. In a short time this one also was opened, and opened extremely wide, but the stomach of the starfish was not thrown out, the animal being satisfied with what he had in hand. The *Venus* was now taken away from the starfish, whereupon it immediately closed, and was laid in a dish with sand. It was not long before it disappeared in the sand in the usual manner, and it afterwards continued quite normal. Specimens of *Venus* were, in a similar way, taken from other starfishes at different stages of the process of opening, and before digestion could commence. The result was always similar to that in the first case described, and the animals showed no trace of maiming or other disturbance. Experiments were also undertaken with gasteropods, and these were even more instructive, because the creatures are much livelier, and therefore promised to show more readily any disturbance of their organism. It was, at the same time, possible easily to observe directly all the details of what took place. I chose for these experiments my old friend *Natica* (sp. *millepunctata* or *ebrea*). Whilst experimenting I made a not uninteresting observation, which completes in a satisfactory way some work which I had formerly published. In a paper on the absorption of water by molluscs,* I had tried to establish the physiological significance of the separate parts of the foot of *Natica*, and in a later paper* I added a further contribution to the subject. I was not quite clear at that time as to the significance of the "shell lobe" (Fig. 2, Sch. Lap.); that is to say, the portion of the foot which, in *Natica josephina* almost entirely, in *N. millepunctata* and *ebrea* only partially, under ordinary circumstances, covers the shell. I have now, however, been able to observe with certainty the use to which this portion of the foot is put. If a few *Natica* be placed in a dish in which there are some *Asterias*, rendered hungry by fasting, the molluscs immediately begin to creep about, and the starfishes endeavour to overpower them. The tube-feet of the *Asterias* are unable to fix themselves to the body of the *Natica* on account of its slimy surface, and there is only left them the uncovered remnant of the shell. (Fig. 2, Sch.) But here also the attachment is prevented, for the moment the *Natica* comes into contact with a starfish it pulls the "shell lobe" of the foot with a jerk over the previously uncovered part of the shell, and thus there is no place left to which the suckers of the *Asterias* can fix. I have observed this proceeding a great many times, and it always takes place so promptly that there can be no doubt as to its connection with the means of defence against starfishes. The drawing of the shell lobe over the shell is brought about by the contraction of the transverse, or, rather, annular muscles of the lobe margin, which act like a sphincter.

---

* SCHIEMENZ, P., "Ueber die Wasseraufnahme bei Lamellibranchiaten und Gastropoden (einschliesslich der Pteropoden)." 2 Theil. *Mitth. Zool. Stat. Neapel.* Bd. 7, pp. 423 472. 1887.

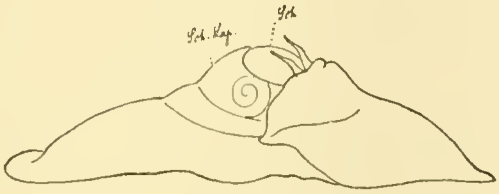


Fig. 2.

In nature, of course, *Natica* hardly comes in contact with *Asterias*, but it does come in contact with *Astropecten*, and it is clear that the tube-feet of that animal, though they are quite pointed at their ends and have no suckers, will slip from the slimy surface of the *Natica* just in the same way as the tube-feet of *Asterias*.

If a *Natica* in the contracted state be given to an *Asterias*, the latter fixes its tube-feet upon all parts of the shell of the mollusc, carries it to its mouth, and tries to digest it. If the *Natica*, however, has lived for some time in the dish and become used to the conditions of confinement, it does not through terror remain closed, but, as a rule, comes out of its shell immediately, and endeavours to free itself from the starfish. A

---

[*] SCHIEMENZ, P., "Wie bohrt Natica die Muscheln an?" *Mitth. Zool. Stat. Neapel.* Bd. 10, pp. 153–169. 1891.

hard fight now commences. As soon as the mollusc begins to protrude its foot, the starfish also throws out its stomach and endeavours to commence the work of digestion. By feeling here and there with the margin of the anterior angle of the foot, which serves as a sense-organ, the gasteropod now tries to find a place somewhere between the tube-feet where there may happen to be a larger space, offering a chance of escape. As is natural, the starfish on its part makes convulsive efforts to hold its victim fast, and block every possible way of escape through the forest of tube-feet. If the *Natica* succeeds in protruding the fore part of its foot sufficiently far for the corners, upon which the apertures for taking in water are situated, to expand themselves, then the battle has been won. When it has made the fore part of the foot swell up a little, it swells the hind part, and from this the shell lobe; whereupon, by drawing the latter closely and tightly over the shell, it sweeps off all the suckers of the starfish. As soon as this has happened the mollusc is free and creeps away unhindered, in spite of the fact that the starfish, during the whole time, has partially covered it with its everted stomach. Thus no maiming by poison has taken place. As a further confirmation, though this was hardly necessary, I took away from the starfish a couple of *Natica* which had not been able to free themselves, and had been already somewhat digested during the fight, and bore wounds. These also recovered; so that there can be no talk of poisoning. Naturally the fight often ends in the destruction of the *Natica*, especially when the starfish has fixed a great number of feet on the operculum and just behind it; for it is then impossible for the mollusc to protrude its foot far enough to be able to swell it up. If the gasteropod perceives the uselessness of the attempt to escape, it withdraws into its shell, closing the latter with the operculum; and then the starfish must first of all open it again. For this purpose there remains one more possibility, namely:

6. *That he opens the shell by force.*—This supposition will be doubtless at first opposed by every reader, who knows from his own experience the strength with which bivalves and gasteropods can keep their shells closed. If, however, we consider the position into which the starfish brings his victim when he wants to open it, the supposition becomes more likely.

With oysters and fixed bivalves and gasteropods, *Asterias* cannot do very much: he must take them as they lie, and cannot alter their position. The circumstances are quite different, however, when he is dealing with a free-living mollusc. If we bring a *Venus* to the end of an arm of a hungry starfish, the first thing it does is to taste it with the long tube-feet, serving as sense-organs, which are situated there. In a few moments the many hundred tube-feet, with which it has been quietly holding on, come to life, and the whole animal pushes itself towards the side at which the mollusc is offered. The arms next to the ones touched are immediately brought near it; and with these three, or perhaps only with two of them, the *Venus* is held fast, the arms being gradually pushed over its shell and one sucker after another made fast to it. But the starfish does not stop moving as soon as the arms have reached the far side of the bivalve, and as fast as they are pushed beyond it the tube-feet fix themselves to the ground. Only when the *Venus* has in this way reached the middle-third of the arm does the starfish cease the forward movement and remain stationary. Meanwhile the bivalve is carried further forward by the tube-feet until it reaches the mouth of the starfish, and is there turned round into such a position that the hinge is below, and the margin of the gape lies exactly opposite the mouth of its enemy. (Fig. 3.) Hamann has already made mention of this position. Whilst this is going on, the starfish raises its body and the portions of its arms next it into a peculiar mound, as represented in Figs. 3 and 4. The only writer I can find who makes mention of this curious attitude is Möbius.* When the starfish is resting on the bottom of the dish, what happens inside this mound, one is not, of course, able to see. In order to find out, the animal must be induced to ascend one of the vertical glass sides of the dish, which is not at all a difficult thing to do. By holding a mollusc in front of it, a hungry starfish may be enticed over considerable distances and led round the dish. If one does this too much, however, it ceases to respond; or, when the mussel is again offered after an interval, begins to crawl away.

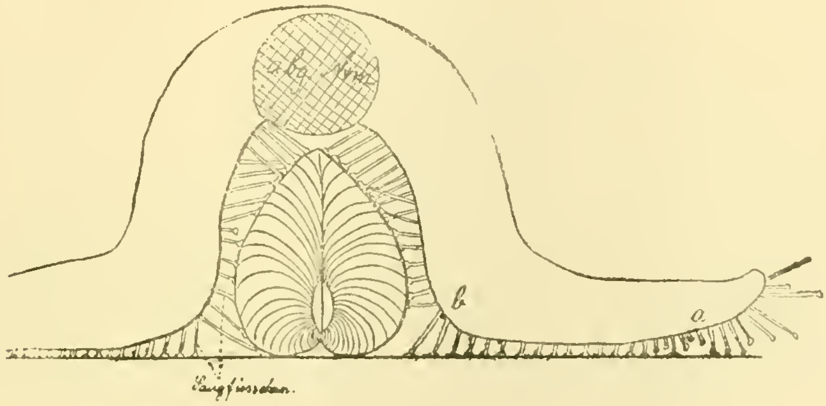


FIG. 3.

It might at first sight appear as if this rising into a mound served only to hinder the victim from escaping. Apparently this is one of the reasons for it; for in assuming the position the arms are pressed together so tightly that not even a crevice is left through which escape could be effected. But a consideration of Fig. 3, which to some extent represents a section of Fig. 4, makes it at once evident that if the starfish intends to open the bivalve by force, he can only do so after he has brought himself and his prey into the positions there represented. I will not here go further into physical considerations, but only remark that the mound itself is extraordinarily rigid, and offers very great resistance to any attempt to press it down. The starfish can now divide its tube-feet in such a way that half of them are fixed to one valve of the shell, the other half to the other; and a pull in opposite directions can be exerted upon the two valves. If the mound formation is adopted in order to open the mussel in the manner indicated, a starfish which is prevented from adopting such a position will not be able to succeed in opening a free bivalve or gasteropod. I therefore made the following experiment: I took a small vertical dish with glass sides, and, by means of a glass plate, separated off a compartment in which there was just depth enough for a starfish to creep, but in which he could not form a mound. When I had put a starfish, which had been prepared by previous fasting, into this small compartment, I offered him a closed *Natica*, which he immediately took. Now whereas, under ordinary conditions, provided a long fight did not take place, a starfish would open a *Natica* in a relatively short space of time,* this starfish wandered round the dish for nearly a whole day, from morning till evening, with his victim—which all the time remained closed—without managing to digest it.

---

* MÖBIUS, K., *Die Auster und die Austerwirthschaft*, p. 120. Berlin, 1877.

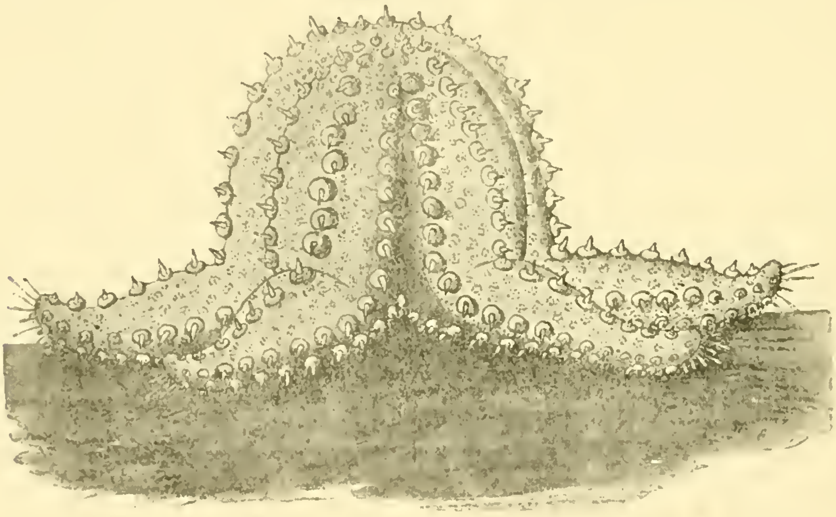


FIG. 4.

It was only towards evening, after many vain attempts, that by all sorts of contortions of his arms he succeeded in forming a mound in a quite unnatural way, namely, between the glass sides and in a position parallel to them. Then he set about opening and digesting the *Natica*. This result clearly confirms the correctness of the above supposition.

---

* There is no need to explain further that gasteropods are opened in exactly the same way as bivalves; some of the tube-feet of the starfish being fixed to the shell itself, whilst others are fixed to the operculum. The gasteropods are brought into an exactly similar position.

In the case of oysters the circumstances are different, in so far that, under natural conditions, these animals are fixed to the ground, and are also considerably larger than the other bivalves. If a starfish, wishing to open an oyster, can find suitable points for fixing his arms on the objects which lie around, it will give him no great trouble to pull his victim apart. Should he not, however, find these, he must form a mound exactly similar to that in Fig. 3. Physical considerations, however, show that under these circumstances, since he must support the portion of the arms marked *a—b* in Fig. 3 on the oyster itself, there will only be a prospect of success when this point of support of the arms lies quite far towards the hinge, or even beyond it, so that the arms can mutually assist each other. There must therefore always be a definite size-relation between the oyster and the starfish; and from this it follows further that large oysters are relatively safe from the attacks of starfishes, whilst small and medium sized ones are specially liable to destruction. Perhaps some day an oyster fisherman will collect evidence on this point. In relation to the matter I must, however, remark that an oyster can only be regarded as successfully attacked when it has been actually opened; and a simple attempt on the part of the starfish of itself proves nothing. In the figures which Collins gives on Plate 165 (Figs. 1 and 2), the size-relation under discussion is clearly seen; and I believe I am not mistaken when I imagine that I can see in the positions of the starfishes in these figures the mound formation which I have described.

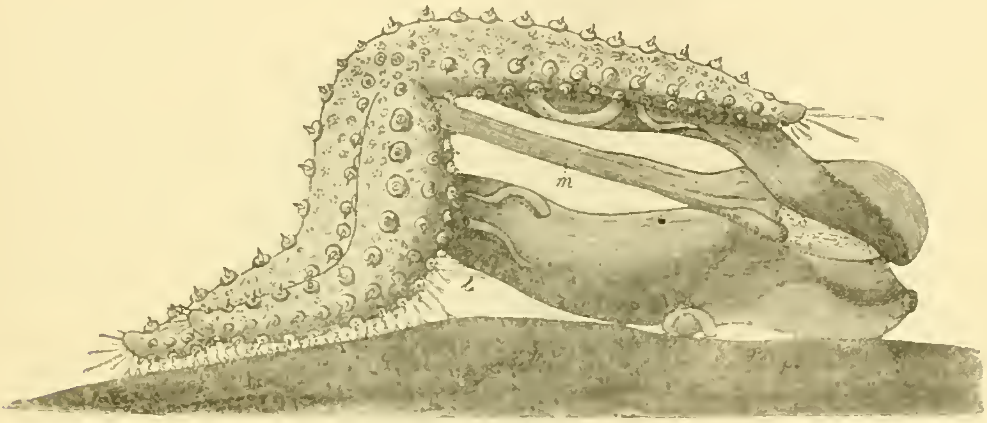


Fig. 5.

In Fig. 5, which I give here from an observation of my own, the starfish has already completed the work of opening; and has, indeed, already digested the greater part of its victim. There is nothing more to be seen of a mound formation, since it is no longer necessary, on account of the destruction of the adductor muscle. I give the figure, nevertheless, because in this case the starfish has made use of the bottom of the dish as the point of support, or attachment, for a portion of the arms. The position of these arms is exactly the same as in Fig. 3: the feet on the parts near their centres (above *b*) being fixed to the oyster's shell, those on the distal parts (*a*) to the bottom of the dish. In the figure is seen also very clearly the manner in which the stomach (*m*) is thrown out, and what a significant position it occupies. That I have not succeeded in this case, as I was able to do with *Venus*, in directly observing the whole process of opening, was due to the fact that the oysters were opened by the starfishes at night. Whether this was accidental or not I cannot say. *Venus* and *Natiea* were taken and opened at whatever time of the day they were offered.

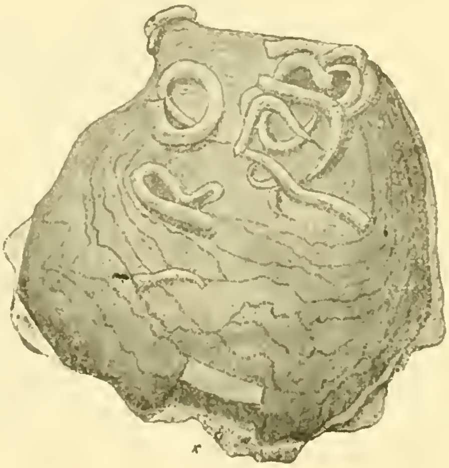


FIG. 6.

An examination of shells which have been eaten out, also shows that the starfish pulls powerfully upon the shell of an oyster which he is about to devour. The margin of oyster shells, at least at Naples, is always more or less laminated. Now, in oysters which have been eaten out, the laminated margin of the upper shell is always broken away for a greater or less distance, until the deeper and stronger layers are reached. Fig. 6 shows such a shell; on which, however, the injured place was specially conspicuous. I need hardly mention that I carefully examined the margins of the oysters before giving them to the starfishes. As no other animals were in the dish excepting oysters and starfishes, the effect upon the shells of the oysters which were eaten could only be due to the starfishes. Moreover, I have seen such broken portions of shell directly attached to the suckers on the feet of a starfish which was resting upon an oyster. Such broken places I have only found on the flat shell, which is clearly due to the curved shell being less laminated, and, therefore, less easily injured.

The points, recognisable by the injury just described, at which *Asterias* opens the oysters, show a certain degree of definiteness in position. They do not, however, as I at first suspected, exhibit a perfectly regular relation to a line drawn through the hinge and the muscle scar. In general, indeed, they lie on this line, and this can be readily understood, since the two shells of the oyster represent, to some extent, two levers, with a fulcrum at the hinge. The further the point of seizure lies from the hinge, that is to say, the longer the arm of the lever, the more effective will be the force applied. Precisely on the longest shells, nevertheless (Fig. 7, Nos. 3, 6, and 10), we find the point of seizure lies, not on the line mentioned, but displaced quite to one side. I can only explain this variation on the supposition that these oysters were of too great length in the direction of the line through the hinge and muscle for the arms of the starfish, and the latter had to find positions in which their arms could reach further over the shell. The point of seizure in these shells always lies on the side which exhibits the less vigorous growth. This seems to be a general rule in all cases in which the oysters show unequal growth (compare also Nos. 7 and 11 in Fig. 7), and possibly depends on the fact that on the side where there is less growth the shells are naturally less laminated, and the starfish, therefore, has more chance of coming to firm portions of the shell, upon which it can effectually fix its tube-feet. In oysters from other localities, whose shells are firm at the

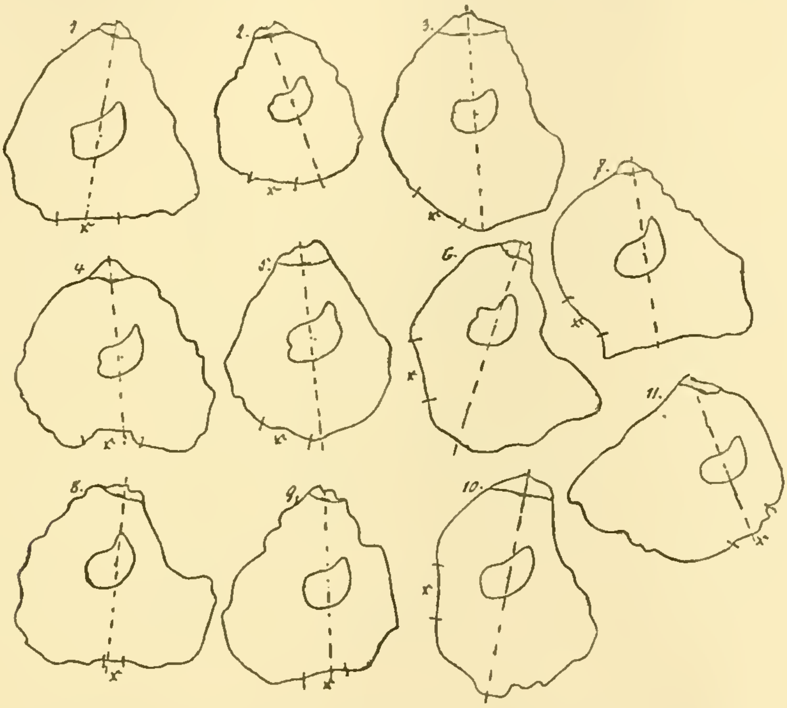


Fig. 7.

margin, and less laminated than those at Naples, such places as those just described, made by breaking away portions of the shell, will naturally not be found. On them, therefore, it will not be possible to ascertain the spot where the starfish has taken hold.

Thus, I have come to the conclusion that the starfish opens the shell of his victim by force, and I must now bring forward proof that the animal does actually possess sufficient strength for the purpose. To do this, the strength of a moderate-sized starfish must first of all be measured. As may be seen from Figs. 3, 4, and 5, the starfish does not use all its tube-feet in opening a bivalve, but, at most, only those on the central halves of the arms. In measuring the strength exerted, the other tube-feet, therefore, must be left out. I succeeded in doing this in the following way:—

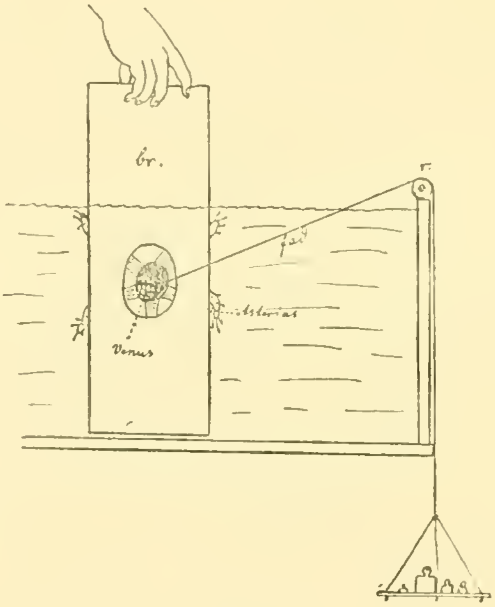


FIG. 8.

A hole was cut in a board of a size corresponding approximately to that of the portion of the starfish which comes into play in opening molluscs. One side of the board was covered with a glass plate (in which was a corresponding hole), giving the starfish the opportunity of attaching itself firmly with the remainder of its tube-feet. An *Asterias* was now enticed with a bivalve on to the board, and the mollusc offered to him through the hole in the board. The bivalve itself was bound round with a string, which was passed, by means of a pulley, over the edge of the dish, and carried at its end a board upon which weights could be placed. After the starfish had taken the mollusc, weights were put on until it let it go. This happened with a weight of 1350 grams. This figure does not, however, represent exactly the strength of the starfish, but is considerably less. Indeed, I have observed that if one endeavours to pull away again a mollusc which has been offered it, a starfish will resist for some time, but if the pull lasts too long, or is too strong, it quite suddenly draws in all its tube-feet, lets the mollusc go, and cannot be persuaded to take it a second time. However, if we accept 1350 grams provisionally as representing the strength of the starfish, we shall, in what follows, be able to show that so much power is far from being necessary for the forcible opening of a moderate-sized *Venus*.

This sounds unlikely, especially since one knows that, according to Lawrence-Hamilton,* a *Venus* can, with its adductor muscles, withstand a strain equal to 2071 times its own weight (without the shell). I have myself seen that, with a momentary weight of 4000 grams, a *Venus* does not think of opening. But the circumstances are completely changed when, instead of a momentary strain, a continuous one is applied. Everyone knows from his own experience that to lift a weight, and to support it for a long time, are two quite different things.

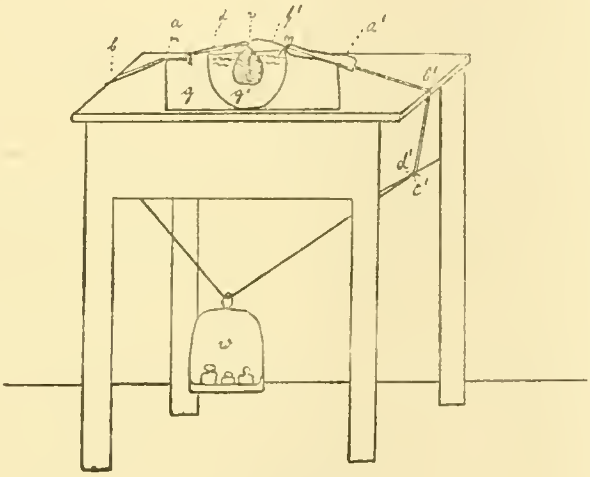


FIG. 9.

In order to investigate the resistance offered by *Venus* to a strain, I had a jar of sea water sent from Naples, followed, some days afterwards, by a number of *Venus verrucosa* (as samples without value) wrapped in moist linen. The latter arrived in Hanover in three days, and were in full vigour, protruding their siphons normally as soon as they were placed in their native element.

In order to measure their strength, I constructed, with the modest appliances at my disposal, the apparatus figured above. (Fig. 9.) The apparatus had to be so devised that the bivalve, whilst remaining in water, could be placed in such a position that a measurement of the extent of opening of the shell could easily be made. A glass dish containing sea water (g) was placed on a small table. In this one stood a smaller but higher dish, also containing sea water, which could be renewed from time to time from the larger one. A *Venus* was now surprised, the handle of a scalpel being placed between the two shells before it had time to close them. The bivalve of course, as soon as the scalpel was put in, closed immediately, and held it fast, and so could easily be taken out. Two flesh-hooks were then taken: a short one made entirely of metal, with two teeth at each end (f), and a second one with a scalpel handle (f'). The two teeth at one end of the short hook were placed in the shell-opening. The teeth of the second hook were also placed in the opening in such a way that they came between the teeth of the short hook. A double string was then slung from the two hinder teeth of the short hook, and a similar string was made fast to the larger one at the beginning of the flat handle. The handle of this hook was placed between the two strings on its own side, so that it was kept in position by them. By this arrangement, with the aid of the friction of the double strings on the edges of the dish (at a and a'), the bivalve was held quite motionless, with the opening upwards. The molluscs were not disturbed by this experimental strain; but, as soon as the shell was far enough open, protruded their siphons and commenced breathing, so that one may say that they were simply normal. Attached to the double strings (at d and d') was a single common string, from the middle of which a scale-pan (w) hung. The weights on this scale-pan were, of course, not all effective, on account of the considerable friction at the points a, b, c, and a', b', c'. In order to determine the true effective weight, I afterwards replaced the bivalve by a spring balance, which was pulled out by the weights. Such spring balances never weigh quite correctly; but in this case one or two grams does not matter, and I give, therefore, in the following tables, only round numbers (friction being allowed for):—

---

* LAWRENCE-HAMILTON, J., "The Limpet's Strength." *Nature*, vol. xlv. p. 487. 1892.

1. *Venus* 4 cm. long, 3·4 cm. broad.

7.55 a.m.,	loaded with 900 grams.
8.10 ,,	commenced to open.
8.15 ,,	open 2 mm.
8.30 ,,	open 3·5 mm.
1.0 p.m.,	open 3·5 mm.
6.10 ,,	open 4 mm.: then set free.

2. *Venus* 3·9 cm. long, 3·2 cm. broad.

6.15 p.m., loaded with 900 grams.
6.20 „ open nearly 2 mm.
6.30 „ open 4 mm.
7.5 „ open 6 mm.
8.7 „ open 5·5 mm. (because a lamp was brought near).
9.0 „ open 6 mm.
9.30 „ open 6 mm.
6.15 a.m. the next morning, open 6 mm.: then set free.

3. *Venus* 4 cm. long, 3·3 cm. broad.

7.0 a.m., loaded with 900 grams.
7.5 „ open 2 mm.
7.10 „ open 3·5 mm.
7.15 „ open 4 mm.
7.30 „ open 5 mm.

Load increased to 1250 grams.

7.38 a.m., load increased to 1700 grams.
7.46 „ load increased to 2000 grams.
8.10 „ open 7 mm.
8.15 „ adductor muscles ruptured.

4. *Venus* 3·6 cm. long, 3 cm. broad.

8.19 a.m., loaded with 900 grams.
8.40 „ open 3 mm.: then set free.

5. *Venus* 3·4 cm. long, 2·8 cm. broad.

8.40 a.m., loaded with 900 grams.
8.56 „ open 1·5 mm.
9.2 „ open 2 mm.
12.27 p.m., open 2·5 mm.

Load increased to 1000 grams.

2.0 p.m., open 2·5 mm.
6.45 „ open 2·5 mm.

Load increased to 1400 grams.

7.15 p.m., open 3 mm.
7.45 „ open over 3 mm.
9.50 „ open 4 mm.: then set free.

6. *Venus* 3·7 cm. long, 3 cm. broad.

9.50 p.m., loaded with 1000 grams.
10.15 „ open 2 mm.
10.30 „ open 4 mm.
11.30 „ open 4 mm.
7.0 a.m. next morning, found with adductor muscles ruptured.

7. *Venus* 3·3 cm. long, 2·8 cm. broad.

8.0 a.m., loaded with 900 grams.
8.24 „ open 1·5 mm.
9.45 „ open 2·5 mm.
10.20 „ open 3·5 mm.: then set free.

Several of the molluscs closed somewhat when approached or disturbed; but as long as the strain was continued they could never shut up completely, even when their soft parts were mechanically irritated. With the exception of the two which were torn apart, they all closed again completely and tightly immediately they were freed from the strain, and when left to themselves behaved quite normally.

It will be seen from the tables that different individuals resist the strain to a very different extent. Generally a weight of 900 grams[*] is quite sufficient to open a *Venus* in from five to twenty-five minutes, or, on an average, fifteen minutes. Further, it follows from experiments 3 and 6 that a strain of 2000, or even 1000 grams. exerted on both shells at once, is sufficient, if continued for some time, to rupture the adductors; whilst, according to the results both of Lawrence-Hamilton's experiments and of my own, not even a weight of 4000 grams is enough to bring about a sudden rupture. The difference in effect between a momentary and a continuous strain is thus most clearly shown.

We saw above that a starfish of moderate size can develop a force of at least 1350 grams with the tube-feet which come into play; so that it possesses more than sufficient strength to forcibly open a *Venus*, since for this purpose at most 900 grams is necessary. The conclusions we have come to are therefore completely confirmed by experiment.

What applies to a *Venus* applies also to an oyster; which, according to Lawrence-Hamilton, can only resist 1919·5 times its own weight (without the shell), and hence is somewhat weaker than *Venus*.

It hardly requires to be stated that every starfish cannot open every oyster or bivalve, and that the size and strength of the two must be in suitable proportion.

---

[*] I have not ascertained how small a load is necessary to cause a slight opening of the shell. It only concerned me to learn whether a weight of 1350 grams is large enough.

In order to afford an idea of the rapidity with which a starfish completely devours an oyster or bivalve, I may mention that a starfish of moderate size had completely digested a *Venus* 3·7 cm. long in 8½ hours, and an oyster 2½ cm. in diameter, which was given it open, in 4 hours.

In conclusion, I would point out that the oyster or mussel culturist should take the greatest pains to destroy starfishes wherever and whenever he can get hold of them. It is not sufficient, however, to tear them up, since they possess an extraordinary power of regeneration, and are able to replace lost parts in a relatively short time. The central body especially plays an important part in this process, and it is probably for this reason that (according to Forbes) regulations exist in certain parts of England which oblige the fishermen to tear or crush the central body of starfishes which they capture, before throwing them overboard. In many districts it would no doubt be worth while to bring the starfishes ashore, and use them as manure. The practical Americans have constructed a special dredge—the "star dredge"—an iron instrument carrying a number of tangles, with which they systematically capture starfishes on the oyster beds.

Algological Notes.

By

George Brebner.

The following is a list of the most important finds since the report in the last number of this Journal.

NEW TO BRITAIN.

MYXOPHYCEÆ.

Oscillatoria rosea, Crn. (Queen's Ground).
**Symploca atlantica*, Gom. f. *purpurea*, Batt. in lit. (Yealm).
**Hyella cæspitosa*, Born. et Flah. var. *nitida*, Batt.

PHÆOPHYCEÆ.

Ralfsia disciformis, Crn. (Yealm).

FLORIDEÆ.

**Acrochætium endophyticum*, Batt. in lit. (Off west-end of Breakwater).
**Cruoria rosea*, Crn. f. purpurea, Batt. (Yealm).
Cruoriopsis cruciata, Duf. (Queen's Ground).
,, *Hauckii*, Batt. (Off west-end of Breakwater).
Peyssonelia rupestris, Crn. (Queen's Ground).

NEW TO PLYMOUTH DISTRICT.

CHLOROPHYCEÆ.

Cladophora hirta, Kütz. (Drake's Island).

PHÆOPHYCEÆ.

Lithoderma fatiscens, Aresch. (plurilocular sporangia, not previously found in Britain.) (Bovisand Bay).
,, *simulans*, (Kuck.) Batt.

FLORIDEÆ.

Acrochætium microscopicum, Näg. (Andern Point).
Peyssonelia Harveyana, Crn. (Queen's Ground).
Rhododermis elegans, Crn. (Queen's Ground, etc.).
Lithothamnion Strömfeltii, Foslie. (Queen's Ground).
Peyssonelia Rosenvingii, Schm. (Wembury Bay).

Those marked thus * are species, or forms, new to science.

The new species of *Acrochætium* is interesting on account of the main part of the thallus being endophytic, the sporangia being raised above the surface of its host *Dasya coccinea*, on short one—to a few-celled stalks. This plant therefore occupies a place in the genus *Acrochætium* similar to that of *Rhodochorton membranaceum* in its genus. The latter plant, however, is not endophytic, but grows within the polypary of various hydrozoa. *A. endophyticum* was described in its barren condition at the Linnean Society's meeting of 19th December, 1895. The sporangia were not found till January, 1896.

Cruoria rosea, Crn. f. *purpurea*, Batt. in lit., is probably only a more advanced stage in the life-history of *Cruoria rosea*, Crn., than had hitherto been recognised. It is so like the figure of Crouan's *Cruoria purpurea* that it would have been identified as such by Mr. Batters and myself but for the fact that our solitary specimen showed several intermediate stages.

Cruoriopsis Hauckii, Batt. in lit., is an interesting member of the Squamariaceæ, dredged off the west end of the Breakwater. The tetraspores showed almost every transition from zonate to cruciate. It most nearly resembles *Cruoriella armorica* of Hauck (non Crouan). As one of the two species bearing the name of *Cruoriella armorica* will have to be re-named, Mr. Batters proposes to call our plant as above.

The other finds do not call for special mention here.

Certain cultivation experiments were carried on which gave interesting results, chiefly with regard to the germination of spores. The most important of these was obtained in the case of *Ahnfeltia plicata*, Fr. The nature of the fructification of this alga had not been satisfactorily cleared up, the late Prof. Fr. Schmitz maintaining that what had hitherto been regarded as the fructifying nemathecium was a parasite. His view, however, while widely accepted by algologists, was opposed by Reinke and others. Specimens of this alga, richly *fruited*, were placed alone in a glass jar, in sterilised sea-water, on the 1st February, 1896, and after two months (30th March) a very great number of germinated spores, in the shape of small discs, were found on the sides and bottom of the glass jar. The structure and appearance of these discs was such as to practically leave no doubt that they were early stages in the growth of *Ahnfeltia plicata*, and not of a parasite. As a result of this experiment, I am strongly of opinion that Prof. Fr. Schmitz's genus *Sterrocolax* will have to be sunk, and in this view I am supported by Mr. Batters. Unfortunately, owing to the difficulties of cultivation, I did not succeed in getting the culture beyond the disc stage. As the Royal Society has generously renewed the grant by the aid of which these investigations are being carried on, I hope to repeat the culture, with more success, when the season comes round again.

As part of my investigation, I am studying the attaching discs of the red sea-weeds, or Florideæ, in order to ascertain to what extent the conditions found in *Dumontia filiformis*, Grev., prevail in other species. So far I have found no other alga which shows a mode of development, from an attaching disc, similar to that described for *D. filiformis*. Cf. "On the Development of the Filamentous Thallus of *Dumontia Filiformis*," *Journal of the Linnean Society*—Botany, vol. xxx. A large number of red sea-weeds (*e.g.* Gigartina, Polyides, Stennogramme, Phyllophora, Ahnfeltia) are connected with their attaching discs by a simple parenchyma-like tissue; one or two forms present different and interesting features in the development of the vertical frond from the attaching base, and when their structure is more fully worked out will, in due course, be described and published, but these conditions in no wise resemble what was found to be the case in *D. filiformis*.

The germination of the spores of *Glœosiphonia capillaris* has yielded interesting results with regard to the mode of formation of the attaching disc. On germinating, the spore sends out a few-celled filament, which by the radiate branching of one or two of the cells forms a well-marked disc.

My friend Mr. Edw. Batters has continued to give me his invaluable aid in the identification of species, &c. Two or three of the above finds are entirely due to him (*e.g. Peyssonelia rupestris*, Crn., *Lithothamnion Strömfeltii*, Foslie), he having recognised them in material forwarded from the Laboratory.

The new species and forms will be described by Mr. Batters in the forthcoming number of the *Journal of Botany* (*i.e.* in September).

SUPPLEMENT TO

Report on the Sponge Fishery of Florida and the Artificial Culture of Sponges.*

By

E. J. Allen, B.Sc.

Hon. Secretary of the Marine Biological Association, and Director of Plymouth Laboratory.

Since the Report on the subject of the Artificial Culture of Sponges was published, some further information of importance relating to the subject has been courteously supplied by the Acting Commissioner of the United States Commission of Fish and Fisheries. This information is in the form of a letter to the United States Commission from Mr. Ralph M. Monroe, of Cocoanut Grove, Biscayne Bay, Florida, to whom the Acting Commissioner refers as "an intelligent and energetic man, whose statements, we think, can be given entire credence," wherein this gentleman gives a detailed account of some experiments conducted by himself at Biscayne Bay, during the years 1889, 1890 and 1891.

The letter, which is published by permission of the Acting Commissioner, is as follows:—

"Cocoanut Grove, Dade Co., Florida,
March 20*th*, 1895.

"U. S. Fish Commission, Washington, D. C.

"Dear Sirs,—Agreeably to request made by you for a brief report on my experiments in sponge culture, I am pleased to submit the following:

Having had my attention called to the possibilities of sponge culture by Mr. J. Fogarty, of Key West, a gentleman of much experience as a buyer and packer of the article, and who had a few years previously successfully grown a few samples from cuttings, I began work in the same line in November, 1889, at Biscayne Bay, a place admirably adapted to such experimenting, far more so than any other place on the coast, having a greater range of bottom from the oozy marls of the inner lagoons to the hard outer coral reef, waters of all degrees of density, from the Gulf Stream to fresh, and currents to suit. Being already well provided with a vessel, boats, sponge hooks, and water glasses, the question of suitable material for attaching to and sinking the cuttings to the bottom gave some trouble, although apparently a simple problem. Saplings of white wood which were plentiful, fairly proof against worms, and heavy enough to retain their place in strong tideways, were finally chosen. They were about 12 feet in length, with a cross piece at one end to prevent rolling over. The cuttings were fastened to them by various contrivances, wedged into holes with pegs, wires around the pole, etc., but the quickest, if possibly not the best, as it afterwards turned out, was short pieces of brass wire doubled and driven into the pole with a peculiar grooved punch, which could be done rapidly. At other stages of the experiment I used bamboo stakes, long double lines of twisted wire connected by cross pieces of white wood, with the cuttings inserted between the strands, also flat pieces of coral rock with drilled holes and wooden wedges. Galvanized iron in any form did not answer, especially wire, as it quickly corroded. Most of the first plantings were lost by its use, and I am also inclined to condemn brass wire on account of the possible poisonous effects of the salts formed on it, although some of the best results were obtained when it was used. Having prepared the sinkers and hooked up sufficient sponge for several days' work, placing them in nets hung from the side of the schooner, the process was as follows: Take the poles or other sinker material in a small boat, two kedge anchors, a small long line, and the sponge in buckets in which the water was changed every few minutes (in this connection, it has been generally understood that exposure to air and sun for even a few minutes was fatal to a sponge, and at first I was very careful in this respect: subsequently I found that several hours of such exposure did not hurt them to any extent: stagnant water, however, will kill them in a very short time), a cutting board and knife, the latter very thin and re-sharpened often, owing to the calcareous matter embedded in the sponge. Having reached the locality which was at first selected by the natural sponge growth already on it, the two kedges are let go at either end of the long line, and by hauling along this line the plantings could be kept quite regular, and when finished were marked by range stakes set up on the adjacent dry banks. The depth of water ranged from eight feet to less than one foot at low tide, at which latter depth many fine sponges are found. By the use of a water glass the plantings could be easily observed at any time without disturbing them. In cutting the sponge it was done as nearly as possible in a line with the radial circulating canals, and that each piece should have on it a part of the outer cuticle. As many were not cut this way, and lived, it may not be at all necessary. Each piece was about one inch square on top and somewhat more in length, coming to a point, averaging 25 to a sponge. In cutting care was taken not to express the natural juices or milk, and quickly attaching to the sinkers, were immediately put into the water. The poles held on an average 12 pieces placed 12 inches apart, and with one assistant I was able to plant about 200 cuttings per day. With a more suitable boat having a well to keep the sponge in, and another assistant, I could easily plant from 600 to 800.

---

* This Journal. Vol. iv. p. 188.

This work was continued with intervals from November, 1889, until June 11, 1891, with various results, under all the conditions of bottom, depth, current, etc. With but few exceptions, the sponge survived the cutting process and began a good healthy growth, to be afterwards lost or destroyed in various ways. In many cases, notably one lot planted back of Elliott's Key in 4 feet of water on hard bottom, 75 per cent. lived and in 6 months had doubled in size; these were mostly taken up before reaching maturity, as a gale would have swept them away, and did so with those that were left. Mature specimens were gotten from many of the other plantings, but the average loss from defective fastenings and other causes was greater. The results can be summed up as follows:

Material for anchoring cuttings: While very many things other than those used suggested themselves in the progress of the work, I kept strictly within the limits of what was economic and practical, therefore poles and stone seemed best suited, preferably the former arranged so as to be elevated a short distance above the bottom to avoid smothering with silt, and to avoid the coral, etc., which is apt to grow in with the sponge. Fastenings of just the right character have yet to be invented.

Location: Anywhere within the bays and lagoons free from heavy sea, too strong current, and too much fresh water, and in moderate depths for easy handling and observation.

Growth: This is faster in strong currents, but shape is apt to be poor and quality harsh. This point, however, is not fully determined. Under favourable conditions the cuttings doubled their size in 6 months; consequently, 18 months to 2 years will produce marketable sponge. The sheepswool was the only one of the useful kinds experimented on, although a few cuttings of velvet, grass, and others, seemed to thrive and do equally well. It is quite possible that with State protection to the planters, and better methods to be determined upon by further experiment, sponge culture might be quite profitable. My belief is, gained in oyster culture from spawn, that a similar method with sponge will eventually prove the correct one, but until more is known of sponge biology it would be useless to suggest methods, notwithstanding the fact that several points in connection with it have been to my mind quite clearly demonstrated. Unfortunately, having had to turn my attention to matters of more immediate pecuniary return, the subject has remained in abeyance.

Very respectfully yours,

(Signed) RALPH M. MONROE."

Variations and Relationship of the Flounder and the Plaice.*

By

F. B. Stead, B.A.

THERE can be no question of the importance of the subjects treated of in this paper; and the results are certainly such as to attract attention. This fact makes it all the more disappointing that the author's method is not calculated to inspire confidence in the accuracy of his conclusions. Before attempting to justify this statement, we may give a brief account of the paper as it stands.

After giving an extensive bibliography, the author passes on in his second chapter to a statement of the method of the investigation, and of the notation by which he finds it necessary to state his results. In the next chapter a table is given showing the extent of variation of particular characters in the species considered, and the degree in which the variations of these same characters in both forms may coincide. The influence of sex and age, and the character and development of the scales, is next treated of, and the following chapter is devoted to a statement of the differences which obtain between the different "local forms" in the North Sea and the Baltic. The rest of the paper is taken up with a consideration of the relations between the local forms and the species, an account of *Pleuronectes pseudoflesus*, certain morphological and biological observations, and a summary of results. We may now consider the more important parts of this paper in detail,

The method of investigation consisted in examining "a large number" of specimens of each species in respect of no less than thirty-six characters. Of these eleven were finally selected as sufficing to distinguish the species one from another, as well as the individual forms of each species from different localities.

---

* "Variation und Verwandschaft von. Pl. flesus L. und Pl. platessa L., untersucht mittelst der Heincke'schen Methode," von Georg Duncker. *Wiss. Meeresuntersuch herausgegeben von d. Komm. zur Wiss. Untersuch d. deutschen Meere in Kiel. Heft. 2, 1896.*

These characters were the number of vertebræ in the caudal peduncle and in the tail, the number of vertebræ which have no median hæmapophysis, and the total number of vertebræ; the number of fin rays in the dorsal and anal fins; the length of the caudal peduncle, and its mean height; the total length of the body without the caudal fin; the length of the head on the ocular side; and the number of branchiostegal rays. In order to eliminate small errors of measurement, such as those which result from the shrinkage of specimens which have been preserved in spirit, and to give at the same time a clearer expression of the main facts of variation, the total range of variation in respect of each particular character was legitimately divided into a small number of arbitrarily selected divisions. Into one of these divisions a number of individuals, all varying slightly from one another, would then fall; and the individuals in question would be regarded as identical in respect of the particular character examined. The author has, however, considered it necessary to adopt a notation to represent the "variation degrees" of each character, which makes his paper by no means easy to read. The several characters of particular individuals are represented by formulæ which the reader has to interpret by reference to the chapter on the method employed, whenever they occur. Thus we are told that the "Extreme Flounder form" has characters represented by the formula $5+19+9=33$. $a\ a\ \delta\ a$ (1).

Having explained his method, the author gives in his next chapter a table, in which the limits of variation for each particular character in the two species considered are indicated.

In two forms so closely allied as the plaice and the flounder, a considerable part of the entire range of variation for any character is often common to the two species.

The table given shows in an interesting manner the degree to which the variation ranges of the several characters are distinct in the two species. Thus the number of fin rays in the dorsal fin varies from 51–65 in the flounder, and from 61–80 in the plaice.

The total range of variation is 30, and of these 30 possible variations there are 5 which are common to both species. This fact is expressed by saying that the percentage of variation common to the two species is 17 per cent. It is noteworthy that in respect of the depth of the body and the length of the head—the measurements in each case being expressed as percentages of the body length—there is no difference in the ranges of variation for the two species.

Our author next deals with the influence of age and sex. This part of the subject appears to us to be somewhat inadequately treated. In dealing with local forms, the author states that he examined exclusively "the grown up" specimens ("erwachsenen materials") without defining the term. An examination of the tables given for plaice reveals the fact that the majority of the specimens examined varied in length from 20–30 cms. (about 8–12 in.). To assume that all these individuals were "grown up," and that the influence of age need not therefore be considered, is to assume what appears to us to require proof. Our author himself points out that the influence of age might be such as to lead an observer to erroneous conclusions with regard to the influence of locality. But he neither investigates the relation of differences in age to any particular character, nor does he examine for each locality a sufficient number of individuals of about the same size to render it probable that the differences due to variation in age may be safely left out of consideration. It is clear that if a sufficiently large number of forms of the same size were examined, the characters for fishes from each locality might be considered in relation to the most probable age for that size. But even so, the influence of the locality on the rate of growth would have to be determined.

With regard to the influence of sex, our author states that in both species the females are always broader, and have longer heads than the males. In the males the number of vertebræ is somewhat smaller than in the females.

The subject of the development of scales in the two species is next considered. To this we would draw special attention, as it is in respect of the character of the scales that the two species differ most strikingly from one another, and the author's observations on the point are distinctly interesting. It is pointed out, that in both species cycloid scales begin to develop (when the fish is 1·5–2·0 cms. long) over the whole surface of the body, at the bases of the caudal fin rays, on the cheeks and on the præoperculum. The plaice develops these scales on the ocular side along the inside rays of the dorsal and anal fins, and at the bases of the pectoral and ventral fins. The scales lie embedded in the skin, separated for the most part from one another, and it is only in particular parts, for instance the caudal peduncle on the ocular side, that they overlap. In the female plaice, development of scales rarely proceeds beyond this stage; in the male, changes may occur after maturity has been reached, but these changes only consist in a transformation of the cycloid scales into the ctenoid condition. In the flounder, on the other hand, the cycloid scales become transformed in various parts of the body into a ctenoid, and even more complicated condition, while the fish is still only 2–3 cms. long.

The change of a cycloid into a ctenoid scale proceeds in the following manner:—The posterior edge of the scale becomes raised out of the enclosing epithelium, and a layer of hard transparent substance bearing spines is laid down over the surface of the scale. This layer, which is divided presumably from the epithelium, travels forwards over the surface to its anterior edge, and spreads over part of the under surface posteriorly. When this process is complete the scale is said to have reached the *Dorn-Stadium.*

In the next chapter the author deals with the different local forms of the plaice and flounder from different localities in the North Sea and the Baltic. We do not propose to give a detailed statement of his conclusions, because it appears to us that the evidence on which these are based is quite insufficient. Taking the first locality dealt with as an example, we may note that the author diagnoses 20 male and 8 female flounders. He then takes the most common measure (in 28 individuals) for each character considered, and writes a formula which he calls *Die Mittelformel für die Königsberge Form.* Further, a table is appended in which the frequencies of the several variations of each character in the individuals examined is expressed in percentages of the total number of individuals. Thus we are informed that *55 per cent. of the 20* male flounders from Königsberg have 36 vertebræ.

It appears to us that little reliance can be placed on conclusions which are drawn from an examination of so small a number of individuals: and it is simply misleading to express the results of such examination in percentages, when fewer even than a hundred individuals have been examined.

The author proceeds to summarise his results by giving two formulæ, expressing the characters of Baltic and North Sea flounders. We are not altogether sure what meaning the author attaches to these generalised formulæ. The formulæ, assuming the results obtained for the separate localities to be accurate, express the most common measurements of the several characters in all the individuals examined from the Baltic and the North Sea, and they may be said to show how in a general way the flounders from these two regions differ from one another in respect to each of the several characters considered. But it would, we think, be a mistake to take these formulæ as expressing the *combined* characters of the ideal form which the environmental forces were tending to produce in these seas. If it is desired to show the direction in which evolution is tending to transform these populations, account must be taken of the facts of correlation. In a paper on certain correlated variations in *Carcinus mœnas,*[*] it has been pointed out by Weldon that before we can estimate the changes at present going on in a race or species, we must know, among other things, (*a*) the percentage of animals which exhibit a given amount of abnormality with regard to a particular character, and (*b*) the degree of abnormality of other organs, which accompanies a given abnormality of one. The *ideal form* of which we spoke above is not to be got at by striking an average for each of the separate characters examined in the individuals from the region in question, but rather by determining not merely the amount of any abnormality, but also the degree to which it is associated with other abnormalities. We think we are right in saying that the laws of correlation do limit, and to some extent determine, the directions which evolution may take. In dealing with local forms, these considerations ought not to be ignored.

---

[*] Weldon. *Proc. Roy. Soc.*, vol 54., p. 318.

We may make our point of view clearer by reference to the formulæ given by our author, which denote what he calls the "extreme flounder form," or the "extreme plaice form." These formulæ are arrived at by taking the extreme variations of the several characters in the flounder and the plaice, contrasting them in this way as much as possible. The formulæ thus obtained represent the sum of a number of separate possibilities; but it by no means follows that the several extreme characters, which are separately possible, are possible in combination with one another in a single individual, and, in point of fact, as an examination of the tables shows, there is not a single instance of either of these extreme forms among the individuals examined by the author.

Our author having, as the result of his investigation into the local forms, taken up the position that the relationship between the two species in the Baltic is closer than in the North Sea, finds support for this view in the existence of an intermediate form which inhabits the south-western part of the Baltic, and which was first described by Gottsche as a variety of the plaice, and named *Pleuronectes pseudoflesus*. This form differs from the flounder in having cycloid scales on its "blind side," and the ctenoid scales of the plaice on its ocular side. It differs, however, from the latter species, and approaches the former in having rows of scales on its lateral line, and on the bases of the dorsal and anal fin rays, which are more highly developed than the ctenoid scales, and represent, in fact, a stage in the development of the scales which is characteristic of the flounder. The question arises, whether it is an intermediate form or a hybrid. On the one hand, the fertility of the fishes would seem to point to the former hypothesis; on the other, the mingling of the specific characters (of the flounder and the plaice), and the rarity of its appearance, would seem to support the latter. Our author inclines to support the latter view, in opposition to Möbius and Heincke, "ohne dass ich einen wissenschaftlichen grund hierfür anzugeben vermöchte."

A form has been described by Ekström and Smitt which is also intermediate between the flounder and the plaice, and differs very slightly from *Pleuronectes pseudoflesus*. This form, to which the name *Pl. glacialis* has been given, is found on the western part of the north coast of North America, and on the north coasts of Asia and Europe.

Attention may now be drawn to the hypothesis concerning the origin of these closely allied forms, which the author tentatively puts forward. It is pointed out in the first place that the Baltic may be considered intermediate between the North Sea and the Arctic Ocean, as regards the populations it contains. Further, the Baltic plaice, which differ from those of the North Sea in the smaller number of their vertebræ and fin rays, and in the stronger and more conspicuous ctenoid scales which they possess (characters which may be said to be masculine), would, if these differences were intensified, come to resemble very closely the Arctic form *Pl. glacialis.* On the other hand, the flounder in the eastern part of the Baltic tends to vary in the direction of a greater number of vertebræ and fin rays, and these characters are feminine. *Pl. glacialis* may, then, be regarded as representing an extreme form of either the plaice with masculine characteristics, or the flounder whose characteristics tend to be feminine. Our author considers that of the forms under consideration, the *plaice,* judging from the rudimentary development of its scales, is the oldest; that this form was originally confined to northern latitudes; and that it wandered thence to the North Sea—without undergoing very much change; and to the northern coasts of Europe and Asia, where it gave rise to the variety *glacialis.* At the same time an immigration took place into the Baltic, through the Gulf of Bothnia, which was then open to the North, and the plaice approximated to the *glacialis* type. As a result of the influence of a mild climate, *Pl. glacialis* became transformed to a flounder-like form. This latter spread over the North Sea and the Atlantic coasts of North America, and gave rise to a number of varieties.

In the meantime the original *Pl. glacialis* of the Baltic disappeared, and this form only now remains in the more northern latitudes where it took its rise. It will be seen that this hypothesis attempts to account for the differences which obtain between the North Sea and Baltic plaice, and derives the flounder from a form like the plaice—the modern *Pl. glacialis* being regarded as representing an intermediate stage in the evolution of the flounder.

In conclusion, we may note that the author carefully refrains from discussing the causes which have given rise to the local varieties he describes. He does not even enter into the question whether the local differences arise in the ontogeny of each individual, as the result of the direct action of the environment, or whether they are inherited: in other words, he does not, so far as we can make out, commit himself as to the real nature of the local varieties—whether they are to be regarded as distinct races or no. He says not a word of Natural Selection or of Lamarckian factors. We are very far from being disposed to complain of these omissions.

In his concluding paragraph the author justifies his research by showing that it points to this important fact, namely, that the morphology of an organism is not wholly dependent on internal formative forces—*e.g.*, Heredity, and Variation due to internal causes—but is also directly influenced in a determinate manner by external, chemical, and physical forces. The author, unless we are much mistaken, is not here concerned with the causes of evolution: he is merely pointing to the fact that every individual is continually subject to external influences, which must have an effect on its structure, whether characters so acquired are inherited or not.

And these external influences may act directly to produce certain modifications in the individual during its lifetime, or indirectly in determining the incidence of selection, or in both of these ways. Leaving out, for the sake of argument, the possibility of inheritance of acquired characters, the external conditions must still be considered of the greatest import—a fact which will be appreciated when it is remembered that an individual cannot be rightly regarded as a naked bundle of characters transmitted from its parents, but as an organism endowed with certain inherited tendencies, and reacting during life to the conditions of its environment. There can be no question, then, of the value of research which is concerned with the examination of the effects of external conditions. And this makes us regret all the more that the author was not as careful in establishing his facts on a sure basis as he is cautious in expressing his opinion on the theoretical aspects of the subject.

Director's Report.

As I was able to announce in a *postscript* to my Report in the last number of the Journal, the Association has secured a small steam fishing yacht, which has already proved exceedingly useful in carrying on the work of the Laboratory. Towards the £600 which was paid for the vessel, a little over £500 has now been subscribed. It is important that the remainder of the sum should be forthcoming, so that it may not be necessary to draw upon our small reserve fund for this purpose.

The number of workers who have visited the Laboratory for the purpose of conducting independent researches has been maintained; and at the same time the arrangement by which students are admitted to the Laboratory for the purpose of study, rather than of research, has been taken advantage of by a much larger number of students than was anticipated.

The following is a list of Naturalists who have occupied research tables, and of the subjects which have engaged their attention:

Brebner, G., September 5th, 1895 (*Marine Algæ*).
Riches, T. H., B.A., January 13th (*Development of Nemertines*).
Garstang, W., M.A., March 23rd to May 1st, July 22nd (*Marine Bionomics*).
Church, A. H., B.A., April 1st to April 25th, July 8th (*Marine Algæ*).
Mac Munn, C. A., June 3rd to 17th (*Blood of Fishes and Invertebrates*).
Cleve, P. T., Ph.D., July 2nd to 7th (*Diatoms*).
Watasé, S., Ph.D., July 3rd to 8th (*Phosphorescence of Marine Animals*).
Weldon, W. F. R., M.A., July 7th (*Variation of Crabs*).
Colcutt, Miss M. C., July 15th (*Hydroids*).
Beer, T., Ph.D., July 27th (*Sense Organs of Crustacea*).
Scott, S. D., B.A., July 28th (*Ascidians*).
Barnard, J. E., August 4th (*Phosphorescent Bacteria*).

In addition to these, *twenty* students have attended the classes conducted by Mr. Garstang. There is every reason to believe that such classes will become a regular feature of the work of the Laboratory, and a useful adjunct to its activities in other directions. Students attending the classes have the opportunity of taking part in the regular collecting work of the Association, and are thus enabled to obtain a good knowledge of marine animals under their natural conditions.

The book which Mr. J. T. Cunningham has recently been preparing, on *The Marketable Marine Fishes of the British Islands,* is to be published for the Association by Messrs. Macmillan and Co., and will appear at an early date. This work, which it is hoped will meet a long-felt want, has been prepared with a view to bringing before the general reader, in a connected narrative form, the information contained in the numerous technical memoirs, which have appeared during the last few years, dealing with marine fishes, their habits, and modes of development. The book is liberally illustrated with process blocks, and should prove exceptionally useful to those who are interested in fishery questions, either for profit or from the legislative point of view.

E. J. ALLEN.

August, 1896.

Marine Biological Association of the United Kingdom.

Report of the Council, 1895–96.

The Council.

Four ordinary and two special meetings of the Council have been held during the year. The average attendance at the meetings has been 9·5. A sub-committee of the Council visited and inspected the Plymouth Laboratory on June 6th.

No vacancy has occurred on the Council itself during the year, but the Council has to deplore the loss of Prof. Huxley, the first President, to whose efforts the successful launching of the Association, and the assistance which it has received from the Government, the City Companies, and other public bodies, were largely due.

The Council has to again thank the Royal Society and the Linnean Society for permitting the meetings of the Association to be held in their rooms.

The Plymouth Laboratory.

Considerable expense has been incurred during the year in repairing the engines and pumps which supply sea-water to the Aquarium. The fact that a circulation has to be continuously maintained causes considerable wear and tear, and constant repairs are necessary to ensure against the possibility of a breakdown. The buildings, fittings, and machinery of the Laboratory are in good condition.

The Boats.

For the first nine months of the year the ordinary collecting work of the Laboratory was done by the sailing-boat *Anton Dohrn*, supplemented from time to time by hired steam tugs. For the fishery investigations conducted by Mr. Stead a small sailing trawler was hired.

The steam-launch *Pansy* has been sold to her former owner, and in February last the Association purchased the steam fishing yacht *Busy Bee* from Mr. Treffry, of Fowey. This boat, which is 60 feet long, and has a gross tonnage of 22·5, is well adapted to the ordinary work of the Association, and is as large a vessel as it would be possible to maintain on our present income. The vessel is in good condition, and it is hoped that she may do good work for the Association for some years to come.

Museum.

Progress has been made in the re-arrangement of the type collection of the local fauna for the Museum, and several of the more important groups are almost complete. The herbarium has also been largely augmented during the year, and should prove valuable to botanists who visit the Laboratory.

The Staff.

The only alteration which has taken place in the staff since the last Annual Meeting has been the appointment of Mr. T. V. Hodgson to the post of Director's Assistant.

Mr. Cunningham still continues to devote himself to investigations connected with the North Sea fisheries, though the Council have to regret that up to the present no special donation has been forthcoming to provide for the continuation of this work.

It is in the direction of an increase in the number of naturalists employed by the Association that we must look for future developments of our work. Now that a more suitable steamboat has been procured, the Laboratory and its appliances may be regarded as sufficiently complete to allow of a much larger amount of useful work being turned out, if a sufficient number of workers can be engaged for lengthened periods.

The Library.

Although that portion of the Library which comprises the literature relating to Sea Fisheries may be regarded as fairly complete, a considerable sum of money will have to be spent before an equally favourable report can be made of the supply of literature dealing with scientific zoology and botany. Not only are we unable, with our present income, to procure regularly many of the important journals, which should find a place in a Library such as ours, but back numbers of journals to which we now subscribe are in many cases deficient. Through the kindness of Sir William Flower, one such defect has been remedied during the year by the completion of our set of the Philosophical Transactions of the Royal Society from the year 1866.

The thanks of the Council are due to the Royal Society, the Zoological Society, the Royal Microscopical Society, and numerous other societies and individuals, at home and abroad, for copies of their publications, by gift or exchange, which have been received.

General Report.

Mr. Cunningham's memoir on the natural history of marketable food fishes, to which reference was made in the last Report, having assumed a larger and more complete form than was at first intended, it has been decided to issue it as a book. The work will be very fully illustrated, and arrangements have been made by which it will be published for the Association by Messrs. Macmillan and Co.

During the summer of last year Mr. Cunningham, in addition to a prolonged stay at Grimsby, visited Scarborough, Lowestoft, and other fishing centres on the East Coast, and by thus extending the field of observation, was able to supplement the work done by Mr. Holt in some important particulars.

Mr. Stead has been carrying out trawling experiments in the Bays on the South Coast of Devon, which are at present closed to trawlers, with a view to determining the nature of the fish populations which they contain at various times of the year.

The ordinary dredging and trawling work carried on from the Plymouth Laboratory has been extended to the deeper water between the Eddystone Rocks and Start Point, and material is being collected for the compilation of a detailed chart of the various grounds in this area, showing the nature of the bottom and the kinds and proportions of the inhabitants at each spot.

Occupation of Tables.

The following naturalists engaged in research work have occupied tables in the Plymouth Laboratory during the year:

P. BARTHELS, Ph.D., Bonn (Echinodermata).
W. I. BEAUMONT, B.A., Cambridge (Faunistic Researches).
A. BETHE, Ph.D., Berlin (Nervous System of Crustacea).
G. BIDDER, M.A., Cambridge (Sponges).
G. BREBNER, Royal College of Science (Marine Algæ).
E. T. BROWNE, B.A., University College, London (Medusae).
A. H. CHURCH, B.A., Oxford (Marine Algæ).
W. GARSTANG, M.A., Oxford (Marine Bionomics).
J. D. GILCHRIST, B.Sc. Ph.D., Edinburgh (Nervous System of Mollusca).
T. V. HODGSON, Mason College (Amphipoda).
T. H. RICHES, B.A., Cambridge (Development of Nemertines).
T. H. TAYLOR, M.A., Yorkshire College, Leeds (Polyzoa).
W. F. R. WELDON, M.A., University College, London (Variation of Crabs).

An important development of the usefulness of the Laboratory has been made by the establishment of vacation classes for advanced university students. Courses of study in Marine Biology have been conducted by Mr. W. Garstang, who was for many years a member of the Association's staff. Eighteen students have taken advantage of this arrangement during the year, the class held at Easter numbering fifteen.

To accommodate this class a room on the ground-floor of the east block of the building has been specially fitted up, so that research workers in the large laboratory are in no way interfered with. It is believed that by thus arousing interest in marine investigations before the students have completed their university course, many of them will be likely to subsequently use the Laboratory for the purpose of scientific research.

Amongst the papers, either wholly or in part the outcome of work done in the Laboratory, which have appeared elsewhere than in the Journal of the Association, are the following:

Allen, E. J.—*Studies on the Nervous System of Crustacea.* Quart. Journ. Micr. Sci. xxxix. p. 33.

Barthels, P.—*Notiz über die Excretion der Holothurien.* Zool. Anzeiger, No. 492. 1895.

Bidder, George.—*The Collar-cells of Heterocoela.* Quart. Journ. Micr. Sci. xxxviii. p. 9.

Browne, E. T.—*On the Variation of Haliclystus octoradiatus.* Quart. Journ. Micr. Sci. xxxviii. p. 1.

Garstang, W.—*Budding in Tunicata.* Science Progress, iii. March, 1895.

Garstang, W.—*Outlines of a new Classification of the Tunicata.* British Association. Ipswich. 1895.

Hickson, S. J.—*The Anatomy of Alcyonium digitatum.* Quart. Journ. Micr. Sci. xxxvii. p. 343.

MacBride, E. W.—*The Development of Asterina gibbosa.* Quart. Journ. Micr. Sci. xxxviii. p. 339.

Nutting, C. C.—*Notes on the Reproduction of Plumularian Hydroids.* Amer. Naturalist, Nov., 1895, p. 966.

Donations and Receipts.

The Receipts for the year include the annual grants from H.M. Treasury (£1000) and the Worshipful Company of Fishmongers (£400), a special donation from Mr. T. H. Riches (£30), annual subscriptions (£153), rent of tables in the Laboratory (£89), sale of specimens (£256), and admission to the Aquarium (£76). In addition to these amounts, the following sums have been promised towards the £600 required for the purchase of the steam yacht *Busy Bee*:

Fishmongers' Company	£105
The Royal Society	£100
J. P. Thomasson, Esq.	£100
Drapers' Company	£52 10s.
Grocers' ,, ...	£50
Mercers' ,, ...	£26 5s.
Goldsmiths' ,, ...	£20
Earl Ducie	£10
Sir Henry Thompson	£10
W. I. Beaumont, Esq. . . .	£1 1s.

making a total of £474 16s. for this purpose.

The total receipts for the year from all sources amount to £2419.

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1896–97:—

President.

Prof. E. RAY LANKESTER, LL.D., F.R.S.

Vice-Presidents.

The Duke of ARGYLL, K.G., K.T., F.R.S.
The Duke of ABERCORN, K.G., C.B.
The Earl of ST. GERMANS.
The Earl of MORLEY.
The Earl of DUCIE, F.R.S.
Lord REVELSTOKE.
The Right Hon. Lord TWEEDMOUTH.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. JOSEPH CHAMBERLAIN, M.P.
The Right Hon. Sir JOHN LUBBOCK, Bart., M.P., F.R.S.
Prof. G. J. ALLMAN, F.R.S.
Sir EDWARD BIRKBECK, Bart., M.P.
Sir WM. FLOWER, K.C.B., F.R.S.
A. C. L. GÜNTHER, Esq., F.R.S.
Prof. ALFRED NEWTON, F.R.S.
Rev. Canon NORMAN, D.C.L., F.R.S.
Sir HENRY THOMPSON.
Rear-Admiral WHARTON, C.B., F.R.S.

Elected Members.

F. E. BEDDARD, Esq., F.R.S.
Prof. F. JEFFREY BELL, F.Z.S.
G. C. BOURNE, Esq., F.L.S.
Sir JOHN EVANS, K.C.B., Treas. R.S.
G. HERBERT FOWLER, Esq.
S. F. HARMER, Esq.
Prof. W. A. HERDMAN, F.R.S.
Prof. S. J. HICKSON, F.R.S.
J. J. LISTER, Esq.
JOHN MURRAY, Esq., F.R.S.
P. L. SCLATER, Esq., F.R.S., Sec. Z.S.
D. H. SCOTT, Esq., F.R.S.
Prof. CHARLES STEWART, F.R.S.
Prof. W. F. R. WELDON, F.R.S.

Hon. Treasurer.

E. L. BECKWITH, Esq.

Hon. Secretary.

E. J. ALLEN, Esq., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

ROBERT BAYLY, Esq.
J. P. THOMASSON, Esq.
THE PRIME WARDEN OF THE FISHMONGERS' COMPANY.
E. L. BECKWITH, Esq. (Fishmongers' Company).
Prof. BURDON SANDERSON, F.R.S. (Oxford University).
Prof. MICHAEL FOSTER, F.R.S. (Cambridge University).
Sir WILLIAM FLOWER, K.C.B., F.R.S. (Brit. Assoc. for Advmnt. of Science).

Dr. ## *Statement of Receipts and Expenditure for the Year ending 31st May, 1896.* Cr.

Receipts.				£	s.	d.	£	s.	d.
To Balance from last year, being Cash in Bank and in hand (General Fund and Bait Investigation Fund)							456	12	2
,, H.M. Treasury							1000	0	0
,, Fishmongers' Company							400	0	0
,, Special Donations—									
Fishmongers' Company				105	0	0			
J. P. Thomasson, Esq.				100	0	0			
Drapers' Company				52	10	0			
Mercers' Company				26	5	0			
T. H. Riches				30	0	0			
Goldsmiths' Company				20	0	0			
Sir H. Thompson				10	0	0			
Earl of Ducie				10	0	0			
J. C. Chapman				2	2	0			
G. P. Bidder				0	10	6			
							356	7	6
,, Annual Subscriptions							153	5	0
,, Rent of Tables	£ 89	7	0						
,, Sale of Specimens	256	10	4						
,, Sale of Journal	20	19	9						
				366	17	1			
,, Sale of Launch *Pansy*				40	0	0			
,, Admission to Tank Room				76	8	4			
,, Interest on Investment				25	18	2			
							509	3	7
,, Balance forward, being overdraft at Bank, less Cash in hand							201	10	3
							£3076	18	6

Expenditure.				£	s.	d.	£	s.	d.
By Salaries and Wages—									
Director				200	0	0			
,, allowance for Assistant				100	16	8			
Naturalist				250	0	0			
Assistant Naturalist				125	0	0			
Wages, &c.				439	17	3			
							1115	13	11
,, Stationery, Office Printing, Postage, &c.							178	3	9
,, Printing Journal				138	2	1			
,, Illustrating do.				4	18	9			
							143	0	10
,, Purchase of Steamer *Busy Bee*							605	0	0
,, Sundry Expenses—									
Gas, Water, Coal, Oil, &c.	£107	9	2						
Coal and Water for Steam Launch	7	15	1						
				115	4	3			
Insurance of Steam Launch				31	13	7			
Stocking Tanks, Feeding, &c.				73	6	9			
Glass, Chemicals, Apparatus, &c.	£223	12	7						
Less Sales of Glass	9	9	9						
				214	2	10			
Maintenance and Renewals of Buildings, Boats, & Nets	£327	5	0						
Less Sales of Nets	0	3	0						
				327	2	0			
Rates and Taxes				7	12	10			
Boat Hire				90	2	7			
Travelling Expenses				34	7	9			
Expenses of Exhibition of Specimens				5	8	4			
Library				74	9	3			
North Sea Investigation				61	9	10			
							1035	0	0
							£3076	18	6

Investment held 31st May, 1896—
£670 Forth Bridge Railway 4 % Guaranteed Stock, at 125 = £837 10 0

Examined and found correct, (Signed) Stephen E. Spring Rice, Edwin Waterhouse, S. F. Harmer, C. Stewart, } *Auditors.*

22nd June, 1896.

LIST
OF
Governors, Founders, and Members.

1st AUGUST, 1896.

I.—Governors.

The British Association for the Advancement of Science, 22, *Albemarle Street, W.*	£500
The University of Cambridge	£500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.*	£509
The Worshipful Company of Fishmongers, *London Bridge*	£3905
The University of Oxford	£500
Bayly, Robert, *Torr Grove, Plymouth*	£1000
Bayly, John (late), *Seven Trees, Plymouth*	£600
Thomasson, J. P., *Woodside, near Bolton*	£950

II.—Founders.

* Member of Council. † Vice-President. ‡ President.

1884	The Corporation of the City of London	£210
1888	The Worshipful Company of Drapers, *Drapers' Hall, E.C.*	£315
1884	The Worshipful Company of Mercers, *Mercers' Hall, Cheapside*	£341 5*s.*
1884	The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*	£100
1889	The Worshipful Company of Grocers, *Poultry, E.C.*	£120
1884	The Royal Microscopical Society, 20, *Hanover Square, W.*	£100
1884	The Royal Society, *Burlington House, Piccadilly, W.*	£350
1884	The Zoological Society, 3, *Hanover Square, W.*	£100
1884	Bulteel, Thos., *Radford, Plymouth*	£100
1884	Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.*	£100
1888	Bury, Henry, M.A., *Trinity College, Cambridge*	£100
1884	Crisp, Frank, LL.B., B.A., Treas. Linn. Soc., 17, *Throgmorton Avenue, E.C.*	£100
1884	Daubeny, Captain Giles A., 30, *Cornwallis Crescent, Clifton, Bristol*	£100
1884	Eddy, J. Ray, *The Grange, Carleton, Shipton, Yorkshire*	£100
1884	Gassiott, John P., *The Culvers, Carshalton, Surrey*	£100
‡*1884	Lankester, Prof. E. Ray, F.R.S., *University Museum, Oxford*	£100

1885	Derby, the Rt. Hon. the late Earl of, K.G.	£100
1884	Lister, S. Cunliffe, *Swinton Park, Masham, Yorkshire*	£100
†1884	Lubbock, The Rt. Hon. Sir John, Bart., M.P., F.R.S., *High Elms, Bromley, Kent*	£100
1884	Poulton, Prof. Edward B., M.A., F.R.S., *Wykeham House, Oxford*	£100
†1889	Revelstoke, Lord, *Membland, Yealmpton, S. Devon*	£100
1890	Riches, T. H., B.A., *Inglenook, Yelverton, S. Devon*	£130
1884	Romanes, G. J., LL.D., F.R.S. (late)	£100
†1889	Thompson, Sir Henry, 35, *Wimpole Street, W.*	£110
*1887	Weldon, Prof. W. F. R., F.R.S., 30A, *Wimpole Street, W.*	£100
1884	Worthington, James (late)	£100

III.—Members.

ann. signifies that the Member is liable to an Annual Subscription of One Guinea.

C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

1884	Alger, W. H., *Manor House, Stoke, Devonport*	*C.*
†1884	Allman, Prof. G. J., F.R.S., *Ardmore, Parkstone, Dorset*	£20
*1895	Allen, E. J., B.Sc., *The Laboratory, Plymouth*	*ann.*
1889	Anderson, Dr. John, 71, *Harrington Gardens, S.W.*	£20
†1884	Argyll, The Duke of, K.G., *Argyll Lodge, Kensington, W.*	*C.*
1885	Armstrong, Lord, C.B., F.R.S., *Crag Side, Rothbury*	*C.*
1893	Ascroft, R. L., 11, *Park Street, Lytham, Lancs.*	*ann.*
1892	Assheton, R., *Birnam, Cambridge*	£20
1890	Badger, A. B., B.A., *Glenleigh, Oakfield Road, Balsall Heath, Birmingham*	*ann.*
1884	Bailey, Charles, F.L.S., *Ashfield, College Road, Whalley Range, Manchester*	*ann.*
1893	Bailey, W. E., *Porth Enys Museum, Penzance*	*C.*
1884	Balfour, Prof. Bayley, F.R.S., *Royal Botanic Gardens, Edinburgh*	*C.*
1893	Bassett-Smith, P. W., Staff-Surgeon, R.N., *H.M.S. Magdala, Bombay*	*ann.*
1884	Bateson, Wm., F.R.S., *St. John's College, Cambridge*	*ann.*
1884	Bayliss, W. Maddock, B.Sc., 52, *Hamilton Terrace, London, N.W.*	*ann.*
1884	Bayly, Miss, *Seven Trees, Plymouth*	£50
1884	Bayly, Miss Anna, *Seven Trees, Plymouth*	£50
1884	Beaumont, W. I., *Angel Hotel, Knutsford*	*ann.*
1885	Beck, Conrad, 68, *Cornhill, E.C.*	*C.*
*1889	Beckwith, E. L., *The Knoll, Eastbourne*	*ann.*
*1887	Beddard, F. E., F.R.S., *Zoological Society's Gardens, Regent's Park, N.W.*	*ann.*
1884	Beddington, Alfred H., 8, *Cornwall Terrace, Regent's Park, N.W.*	*C.*
*1884	Bell, Prof. F. Jeffrey, 35, *Cambridge Street, Hyde Park, W.*	*ann.*
1887	Berrington, A. D., *Board of Trade, Whitehall, S.W.*	*ann.*
1890	Bidder, George, B.A., *Ravensbury Park, Mitcham, Surrey*	*C.*
1885	Bignell, Geo. Carter, F.E.S., 85, *Union Street, Stonehouse, Plymouth*	*ann.*
†1885	Birkbeck, Sir Edward, Bart., M.P., 10, *Charles Street, Berkeley Square, W.*	*ann.*
1893	Bles, A. J. S., *Palm House, Higher Broughton, Manchester*	*ann.*
1889	Bolitho, T. B., M.P., *Trewidden, Penzance*	*ann.*

1884 Bompas, G. C., 121, *Westbourne Terrace, Hyde Park* .... *ann.*
1884 Bossey, Francis, M.D., *Mayfield, Redhill, Surrey* .... *ann.*
1884 Bostock, E., *Stone, Staffordshire* .... *ann.*
1890 Bourne, Prof. A. G., F.R.S., *The Presidency College, Madras* .... *ann.*
*1884 Bourne, Gilbert C., *New College, Oxford* .... *ann.*
1886 Brent, Francis, F.S.A., 6, *Tothill Avenue, Plymouth* .... *ann.*
1895 Bridge, Prof. T. W., *Mason College, Birmingham* .... *ann.*
1890 Brindley, H. H., M.A., *St. John's College, Cambridge* .... *ann.*
1886 Brooksbank, Mrs. M., *Leigh Place, Godstone, Surrey* .... *C.*
1884 Brown, Arthur W. W., 6, *Sussex Square, W.* .... *C.*
1893 Browne, Edward T., 141, *Uxbridge Road, N.W.* .... *ann.*
1893 Buchanan, Miss Florence, *The Museum, Oxford* .... *ann.*
1884 Buckton, G. B., *Weycombe, Haslemere* .... *ann.*
1886 Bullar, Miss Anna K., *Westbourne Hill, Southampton* .... *ann.*
1887 Burd, J. S., *Cresswell, Higher Compton, Plymouth* .... *ann.*
1889 Burnard, Robert, 3, *Hillsborough, Plymouth* .... *ann.*

1884 Caine, H. T., 5, *Upper Wimpole Street, London, W.* .... *C.*
1884 Caine, W. S., *The Terrace, Clapham Common, S.W.* £21
1887 Caldwell, W. H., 12, *Harvey Road, Cambridge* .... *C.*
1887 Carter, James, F.G.S., 30, *Petty Cury, Cambridge* .... *ann.*
†1884 Chamberlain, Rt. Hon. J., M.P., 40, *Princes Gardens, S.W.* .... *ann.*
1884 Christy, Thomas Howard, *Malvern House, Sydenham* .... *ann.*
1887 Clarke, Rt. Hon. Sir E., Q.C., M.P., 5, *Essex Court, Temple, E.C.* £25
1884 Clay, Dr. R. H., *Windsor Villas, Plymouth* .... *ann.*
1885 Clerk, Major-Gen. H., F.R.S., 40, *St. Ermin's Mansions, Caxton Street, S.W.* £21
1886 Coates and Co., *Southside Street, Plymouth* .... *C.*
1885 Collier Bros., *Old Town Street, Plymouth* .... *C.*
1890 Cook, C. H., M.A., *Elmlea, South Stoke, Reading* .... *ann.*
1895 Corderoy, A., 13, *Athenæum Street, Plymouth* .... *ann.*
1889 Crossman, Major-General Sir William, K.C.M.G., *Cheswick, Northumberland* .... *ann.*

1885 Darwin, Francis, F.R.S., *Wychfield, Cambridge* .... *C.*
1885 Darwin, W. E., *Ridgemount, Bassett, Southampton* £20
1889 Davies, H. R., *Treborth, Bangor* .... *ann.*
1889 Deacon, J. Barrington, 11, *Osborne Place, Plymouth* .... *ann.*
1885 Dendy, Arthur, D.Sc., *Victoria University, Melbourne* .... *ann.*
1884 Dewick, Rev. E. S., M.A., F.G.S., 26, *Oxford Square, Hyde Park, W.* ... *C.*
1885 Dixey, F. A., M.A., Oxon., *Wadham College, Oxford* .... £26 5*s.* *and ann.*
1890 Driesch, Hans, Ph.D., *Stazione Zoologica, Napoli* .... *C.*
†1889 Ducie, The Rt. Hon. the Earl of, F.R.S., *Tortworth Court, Falfield, R.S.O.* £50 15*s.*
1884 Dunning, J. W., 4, *Talbot Square, W.* .... £26 5*s.*
1884 Dyer, W. T. Thiselton, M.A., C.M.G., F.R.S., *Director of the Royal Gardens, Kew* .... *C.*

1893 Edward, Stanley, F.Z.S., *Kidbrook Lodge, Blackheath, S.E.* .... *ann.*
1891 Ellis, Hon. Evelyn, *Rosenais, Datchet, Windsor* .... *C.*
1893 Enys, John Davies, *Enys, Penryn, Cornwall* .... *ann.*
*1884 Evans, Sir John, D.C.L., Treas. Roy. Soc., *Nash Mills, Hemel Hempstead* £20
1885 Ewart, Prof. J. Cossar, M.D., *University, Edinburgh* £25

1884	Fayrer, Sir Joseph, Bart., M.D., F.R.S., 53, *Wimpole Street, W.*	*ann.*
1894	Ferrier, David, M.A., M.D., F.R.S., 34, *Cavendish Square, W.*	*ann.*
1884	Fison, Frederick W., *Greenholme, Burley-in-Wharfedale, Leeds*	*C.*
*†1884	Flower, Sir W. H., K.C.B., F.R.S., *Director of the British Museum of Natural History, Cromwell Road, S.W.*	*C.*
*1885	Fowler, G. Herbert, B.A., Ph.D., 12, *South Square, Gray's Inn, W.C.*	*ann.*
1884	Fox, George H., *Wodehouse Place, Falmouth*	*ann.*
1889	Fraser, James, *Tregarthyn, Eton Avenue, N.W.*	*ann.*
1886	Freeman, F. F., *Abbotsfield, Tavistock, S. Devon*	*C.*
1884	Fry, George, F.L.S., *Carlin Brae, Berwick-on-Tweed*	£21
1884	Fryer, Charles E., *Board of Trade, S.W.*	*ann.*
1892	Galton, F., F.R.S., 42, *Rutland Gate, S.W.*	*ann.*
1885	Gaskell, W. H., F.R.S., *The Uplands, Shelford, Cambridge*	*C.*
1885	Gaskell, E. H., *North Hill, Highgate, N.*	*C.*
1893	Gatty, Charles Henry, LL.D., F.L.S., *Felbridge Place, East Grinstead*	*C.*
1884	Gibson, Ernest, F.Z.S., c/o Fraser, Stoddart, and Ballingall, 16, *Castle Street, Edinburgh*	*ann.*
1884	Gonne, William	£26 5*s.*
1885	Gordon, Rev. J. M., *St. John's Vicarage, Redhill, Surrey*	*ann.*
1885	Gotch, Prof. F., F.R.S., *University Museum, Oxford*	*ann.*
1888	Goulding, F. H., *George Street, Plymouth*	*C.*
1884	Grove, E., *Norlington, Preston, Brighton*	*ann.*
1884	Groves, J. W., c/o Rev. J. Farmer, *Ongar Rectory, Sussex*	*ann.*
†1884	Günther, Dr. Albert, F.R.S., 2, *Lichfield Road, Kew Gardens*	*ann.*
1884	Haddon, Prof. Alfred C., M.A., *Innisfail Hill Road, Cambridge*	*ann.*
1884	Halliburton, Prof. W. D., M.D., B.Sc., *King's College, Strand, W.C.*	*ann.*
1884	Hannah, Robert, 82, *Addison Road, Kensington, W.*	*C.*
*1885	Harmer, S. F., *King's College, Cambridge*	*C.*
1889	Harvey, T. H., *Cattedown, Plymouth*	*ann.*
1888	Haselwood, J. E., 3, *Lennox Place, Brighton*	*C.*
1884	Haslam, Miss E. Rosa, *Ravenswood, Bolton*	£20
1884	Hayne, C. Seale, M.P., 6, *Upper Belgrave Street, S.W.*	*ann.*
1884	Head, J. Merrick, F.R.G.S., J.P., *Ardverness, Reigate*	*ann.*
1884	Heape, Walter, *Heyroun, Chaucer Road, Cambridge*	*C.*
1887	Heath, Miss A., *Yelverton*	*ann.*
*1884	Herdman, Prof. W. A., F.R.S., *University College, Liverpool*	*ann.*
1884	Herschel, J., Col., R.E., F.R.S., *Observatory House, Slough, Berks.*	*C.*
1884	Heywood, James, F.R.S., 26, *Palace Gardens, W.*	*C.*
1889	Heywood, Mrs. E. S., *Light Oaks, Manchester*	*C.*
*1884	Hickson, Prof. Sydney J., M.A., D.Sc., F.R.S., *Ellesmere House, Wilenslow Road, Withington, Manchester*	*ann.*
1884	Holdsworth, E. W. H., F.L.S., F.Z.S., *Lucerne House, Dartmouth*	*ann.*
1893	Holt, Mrs. Vesey W., 104, *Elm Park Gardens, S.W.*	*ann.*
1889	Howell, Mrs. F. Bullar, *Ethy, Lostwithiel*	*ann.*
1887	Howes, Prof. G. Bond, F.L.S., *Science and Art Department, South Kensington*	*ann.*
1884	Hudleston, W. H., M.A., F.R.S., 8, *Stanhope Gardens, South Kensington, S.W.*	*ann.*
1885	Hurst, C. Herbert, Ph.D., *Royal College of Science, Dublin*	*C.*

1891	Indian Museum, Calcutta, 65, *Cornhill*	*ann.*
1888	Inskip, Capt. G. H., R.N., 22, *Torrington Place, Plymouth*	*ann.*
1893	Jago, Edward, *Menheniot, Cornwall*	*ann.*
1887	Jago-Trelawny, Major-Gen., F.R.G.S., *Coldrenick, Liskeard*	*C.*
1890	Johnson, Prof. T., D.Sc., F.L.S., *Royal College of Science, Dublin*	*ann.*
1892	Joshua, Mrs., 57, *Cadogan Square, S.W.*	*ann.*
1894	Justen, F. W., F.Z.S., c/o Dulau and Co., 37, *Soho Square, W.*	*ann.*
1884	Kellock, W. B., F.L.S., F.R.C.S, 94, *Stamford Hill, N.*	*ann.*
1884	Kent, A. F. S., *Physiological Laboratory, St. Thomas's Hospital, S.W.*	*ann.*
1885	Langley, J. N., F.R.S., *Trinity College, Cambridge*	*C.*
1885	Lea, A. S., M.A., *Caius College, Cambridge*	*ann.*
*1895	Lister, J. J., M.A., *St. John's College, Cambridge*	*ann.*
1884	London, The Lord Bishop of, *The Palace, Fulham, S.W.*	*ann.*
1888	Lopes, The Rt. Hon. Sir Massey, Bart., *Maristow, Roborough, South Devon.*	*ann.*
1885	Macalister, Prof. A., F.R.S., *St. John's College, Cambridge*	*ann.*
1884	Mackrell, John, *High Trees, Clapham Common, S.W.*	*C.*
1886	MacMunn, Charles A., *Oak Leigh, Wolverhampton*	*ann.*
1889	Makovski, Stanislaus, *Fairlawn, Red Hill*	*ann.*
1885	Marr, J. E., M.A., *St. John's College, Cambridge*	*C.*
1884	Mason, Philip Brookes, *Burton-on-Trent*	*ann.*
1884	McAndrew, James J., *Lukesland, Ivybridge, South Devon*	*ann.*
1884	McIntosh, Prof. W. C., F.R.S., 2, *Abbotsford Crescent, St. Andrews, N.B.*	*C.*
1894	Meryon, Capt. J. E., R.N., *H.M.S. Katoomba, Australian Squadron*	*ann.*
1884	Michael, Albert D., *Cadogan Mansions, Sloane Square, S.W.*	*C.*
1885	Mitchell, P. Chalmers, B.A., 79, *Portsdown Road, Maida Vale*	*ann.*
1885	Mocatta, F. H, 9, *Connaught Place, W.*	*C.*
1886	Mond, Ludwig, F.R.S., 20, *Avenue Road, Regent's Park, N.W.*	*C.*
1884	Morgan, Prof. C. Lloyd, *University College, Bristol*	*ann.*
1891	Morgans, Thomas, *The Guildhall, Bristol*	*ann.*
†1889	Morley, The Rt. Hon. the Earl of, 31, *Prince's Gardens, S.W.*	*ann.*
1885	Morris, John	£21
1885	Morrison, Alfred, 16, *Carlton House Terrace*	£52 10*s.*
†1884	Newton, Prof. Alfred, M.A., F.R.S., *Magdalen College, Cambridge*	£20
†1884	Norman, Rev. Canon, M.A., D.C.L., F.R.S., *Houghton-le-Spring Rectory, Co. Durham*	*ann.*
1884	Ommanney, Admiral Sir Erasmus, K.C.B., F.R.S., 29, *Connaught Square, W.*	*ann.*
1885	Paget, Sir James, Bart., F.R.S., 5, *Park Place, W.*	*C.*
1884	Parsons, Chas. T., *Norfolk Road, Edgbaston, Birmingham*	*ann.*
1888	Peek, Sir Henry W., Bart., F.Z.S., *Wimbledon House, Wimbledon*	*C.*
1888	Pennsylvania, University of, *Philadelphia, U.S.A.*	*ann.*

1885	Phillips, Chas. D. F., M.D., 10, *Henrietta Street, Cavendish Square, W.*	*C.*
1887	Phipson, Mrs., *Cumballa Hill, Bombay*	*ann.*
1895	Pinwill, Capt. *Trehane, Probus, Cornwall*	*ann.*
1885	Pochin, H. D., *Bodnant Hall, Eglwysbach, Denbighshire*	*C.*
1886	Power, Henry, F.R.C.S., 37A, *Great Cumberland Place, W.*	*ann.*
1885	Pritchard, Prof. Urban, 26, *Wimpole Street, W.*	*ann.*
1884	Pye-Smith, P. H., M.D., 54, *Harley Street, W.*	*C.*
1893	Quintin, St. W. H., *Scampstone Hall, Rillington, Yorks*	*ann.*
1884	Radford, Daniel, *Mount Tavy, Tavistock*	*ann.*
1884	Ralli, Mrs. Stephen, 32, *Park Lane, W.*	£30
1885	Ransom, W. B., *The Pavement, Nottingham*	*C.*
1893	Rashleigh, E. W., *Kilmarth, Par Station, Cornwall*	*ann.*
1888	Rawlings, Edward, *Richmond House, Wimbledon Common*	*ann.*
1892	Robinson, Miss M., *University College, London, W.C.*	*ann.*
1892	Rüffer, M.A., M.D., *Bactereological Institute, Cairo*	*ann.*
1888	Scharff, Robert F., Ph.D., *Science and Art Museum, Dublin*	*ann.*
*1884	Sclater, P. L., F.R.S., Sec. Zool. Soc., 3, *Hanover Square, W.*	*ann.*
1884	Sclater, W. L., *The Museum, Cape Town*	*ann.*
*1885	Scott, D. H., M.A., Ph.D., F.R.S., *Old Palace, Richmond, Surrey*	*C.*
1884	Sedgwick, A., M.A., F.R.S., *Whitefield, Great Shelford, Cambridge*	*C.*
1888	Serpell, E. W., 19, *Hill Park Crescent, Plymouth*	£50
1885	Sheldon, Miss Lilian, *Oldall, Newnham College, Cambridge*	*ann.*
1884	Shipley, Arthur E., M.A., *Christ's College, Cambridge*	*C.*
1886	Shore, T. W., M.D., *The Warden's House, St. Bartholomew's Hospital, E.C.*	*ann.*
1894	Simpson, F. C., J.P., *Maypool, Churston Ferrers, R.S.O.*	*ann.*
1885	Sinclair, F. G., *New Museums, Cambridge*	*C.*
1891	Sinclair, William F., 102, *Cheyne Walk, Chelsea, S.W.*	*C.*
1884	Skinners, the Worshipful Company of, *Skinners' Hall, E.C.*	£42
1889	Slade, Commander, E. J. Warre, *H.M.S. Cockatrice, Mediterranean Station*	*C.*
1884	Sladen, W. Percy, 13, *Hyde Park Gate, S.W.*	*ann.*
1893	Sorby, H. C., LL.D., F.R.S., *Broomfield, Sheffield*	*ann.*
1888	Spencer, Prof. W. Baldwin, M.A., *University of Victoria, Melbourne*	*ann.*
1884	Spring-Rice, S. E., C.B., 1, *Bryanston Place, Bryanston Square, W.*	*C.*
*1884	Stewart, Prof. Chas., F.R.S., *Royal College of Surgeons, Lincoln's Inn Fields, W.C.*	*ann.*
1884	Sutherland, The Duke of, K.G., *Stafford House, St. James', S.W.*	*C.*
1894	Sykes, E. R., 3, *Gray's Inn Place, Gray's Inn, London, W.C.*	*ann.*
1894	Thomas, W. F., *Bishopshalt, Hillingdon, Middlesex*	*ann.*
1890	Thompson, H. F., B.A., 35, *Wimpole Street, W.*	*ann.*
1884	Thornycroft, John I., *Eyot Villa, Chiswick Mall*	*ann.*
1888	Thurston, Edgar, *Government Central Museum, Egmore, Madras*	*ann.*
1888	Tripe, Major-General, 3, *Osborne Villas, Stoke, Devonport*	*ann.*
1888	Vallentin, Rupert, 18, *Kimberley Road, Falmouth*	*ann.*
1891	Vaughan, Henry, 28, *Cumberland Terrace, N.W.*	*ann.*

1884 Venning, Mrs., 3, *Wingfield Villas, Stoke, Devonport* £50
1884 Vines, Professor Sydney H., M.A., D.Sc., F.R.S., *Botanical Gardens, Oxford* .... *ann.*

1884 Walker, Alfred O., *Nantyglyn, Colwyn Bay, N. Wales* .... *ann.*
1884 Walker, P. F., 36, *Princes Gardens, S.W.* .... *ann.*
1893 Walker, W. H., 3, *Princess Place, Plymouth* .... *ann.*
†1884 Walsingham, Lord, F.R.S , *Merton Hall, Thetford* £20
1890 Waterhouse, Edwin, 44, *Gresham Street, E.C.* .... *ann.*
1890 Were, Nicholas, 9, *Osborne Place, Plymouth* .... *ann.*
1895 Wickham, Rev. T. D. C., *Horsington Rectory, Templecombe, Somerset* ... *ann.*
1891 Wildy, A. G., 13, *Furnival's Inn, E.C.* .... *ann.*
1884 Wilson, Scott B., *Heather Bank, Weybridge Heath* .... *C.*
1884 Woodall, John W., M.A., F.G.S., *St. Nicholas House, Scarborough* ...... *ann.*

1891 Young, Sydney, M.D., 13, *Aberdeen Terrace, White Ladies Road, Bristol.* *ann.*

IV.—Associate Members.

1889 Alward, George, 11, *Hainton Street, Great Grimsby.*
1889 Caux, J. W. de, *Great Yarmouth.*
1889 Dannevig, Capt. G. M., *Arendal, Norway.*
1889 Dunn, Matthias, *Mevagissey.*
1889 Olsen, O. T., F.L.S., F.R.G.S., *Fish Dock Road, Great Grimsby.*
1889 Ridge, B. J., 3, *Gainsboro' Place, Mutley, Plymouth.*
1890 Roach, W., 4, *Gascoyne Place, Plymouth.*
1889 Shrubsole, W. H., 62, *High Street, Sheerness-on-Sea.*
1889 Sinel, Joseph, 2, *Peel Villas, Cleveland Road, Jersey.*
1890 Spencer, R. L., *L. and N.W. Depôt, Guernsey.*
1890 Wells, W., *The Aquarium, Brighton.*
1890 Wiseman, Fred., *Buckland House, Paglesham, Rochford, Essex.*

OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Professor LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence, the Association has erected at Plymouth a thoroughly efficient Laboratory, where naturalists may study the history of marine animals and plants in general, and where, in particular, researches on food fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent, for the use of a working table in the Laboratory, and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year. must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter, the payment of servants and fishermen, the hire and maintenance of fishing boats, and the salary of the Resident Director and Staff. At the commencement of this number will be found the names of the gentlemen on the staff. In no case does any one salary exceed £250.

The Association has received some £25,000, of which £11,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £7,000.

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS OF NEW SERIES, Vol. IV., No. 3.

PAGE

1. CONTRIBUTIONS TO MARINE BIONOMICS. I. THE HABITS AND RESPIRATORY MECHANISM OF CORYSTES CASSIVELAUNUS. By WALTER GARSTANG, M.A. 223
2. PHYSICAL AND BIOLOGICAL CONDITIONS IN THE NORTH SEA. By J. T. CUNNINGHAM, M.A. 233
3. NOTE ON A SPECIMEN OF ECHINORHINUS SPINOSUS. By F. B. STEAD, B.A. 264
4. HOW DO STARFISHES OPEN OYSTERS? By DR. PAULUS SCHIEMENZ (Translated from the German by E. J. ALLEN) 266
5. ALGOLOGICAL NOTES. By GEORGE BREBNER 286
6. SUPPLEMENT TO REPORT ON THE SPONGE FISHERY OF FLORIDA, AND THE ARTIFICIAL CULTURE OF SPONGES. By E. J. ALLEN, B.Sc. . 289
7. VARIATIONS AND RELATIONSHIPS OF THE FLOUNDER AND THE PLAICE. By F. B. STEAD, B.A. 293
8. DIRECTOR'S REPORT 300
9. REPORT OF COUNCIL, 1895-96 302
10. LIST OF GOVERNORS, FOUNDERS, AND MEMBERS, 1st AUGUST, 1896 . 308

NOTICE.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for statements published in this Journal, excepting when those statements are contained in an official report of the Council.

TERMS OF MEMBERSHIP.

		£	s.	d.
Annual Members	per annum.	1	1	0
Life Members	Composition Fee.	15	15	0
Founders		100	0	0
Governors		500	0	0

Members of the Association have the following rights and privileges; they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

All correspondence should be addressed to the Director, The Laboratory, Plymouth.

New Series.—Vol. IV., No. 4—issued March, 1897.] [Price 3s. 6d.

Journal

AP… 22 1897

OF THE

MARINE BIOLOGICAL ASSOCIATION

11,974

OF

THE UNITED KINGDOM.

THE PLYMOUTH LABORATORY.

PLYMOUTH:
PRINTED FOR THE MARINE BIOLOGICAL ASSOCIATION BY W. BRENDON & SON,
AND
PUBLISHED BY THE ASSOCIATION AT ITS OFFICES ON THE CITADEL HILL.

SENT FREE BY POST TO ALL MEMBERS OF THE MARINE BIOLOGICAL ASSOCIATION:
ANNUAL SUBSCRIPTION FOR MEMBERSHIP, ONE GUINEA.

Agents in London:—Messrs. DULAU & Co., 37, Soho Square, W.

PATRON.

H.R.H. THE PRINCE OF WALES, K.G., F.R.S.

OFFICERS AND COUNCIL.

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G., K.T., F.R.S.
The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Revelstoke.
The Right Hon. Lord Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Sir John Lubbock, Bart., M.P., F.R.S.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart.
Sir Wm. Flower, K.C.B., F.R.S.
Dr. A. C. L. Günther, F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson.
Rear-Admiral Wharton, C.B., F.R.S.

COUNCIL.

Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffrey Bell, F.Z.S.
G. C. Bourne, Esq., F.L.S.
Sir John Evans, K.C.B., D.C.L., Treas. R.S.
G. Herbert Fowler, Esq.
S. F. Harmer, Esq.
Prof. W. A. Herdman, F.R.S.
Prof. Sydney J. Hickson, F.R.S.
J. J. Lister, Esq.
John Murray, Esq., F.R.S.
D. H. Scott, Esq., F.R.S.
P. L. Sclater, Esq., F.R.S. (Sec. Zool. Soc.)
Prof. Charles Stewart, F.R.S.
Prof. W. F. R. Weldon, F.R.S.

Governors.

Robert Bayly, Esq.
J. P. Thomasson, Esq.
The Prime Warden of the Fishmongers' Company
E. L. Beckwith, Esq. (Fishmongers' Company)
Prof. Burdon Sanderson, F.R.S. (Oxford University).
Prof. Michael Foster, F.R.S. (Cambridge University).
Sir Wm. Flower, K.C.B. F.R.S. (Brit. Assoc. for Advancement of Science).

Hon. Treasurer.

E. L. Beckwith, Esq., The Knoll, Eastbourne.

PERMANENT STAFF.

Director and Hon. Sec.—E. J. Allen, Esq., B.Sc., The Laboratory, Citadel Hill, Plymouth.

Assistant to the Director—T. V. Hodgson, Esq.

APR 22 1897

On the Peculiarities of Plaice from Different Fishing Grounds.

By

J. T. Cunningham, M.A.

THE investigation here described may be regarded as the natural sequel of the observations by which I showed that the plaice of the Brown Ridges, as well as those from the Plymouth grounds, were smaller when they attained to sexual maturity than those of the northern part of the North Sea. Mr. Holt, in 1894, published in this Journal some observations on the dwarfed and ciliated or spinulated plaice of the Baltic; and Dr. Heincke, now Director of the German Biological Station at Heligoland, had suggested as a probability that the plaice of the Heligoland region were a smaller geographical race, distinguishable by special characters from those of other regions. I referred to this subject at the end of my paper on the Physical and Biological Conditions in the North Sea, in the preceding number of this Journal, and mentioned the paper in which Georg Duncker* has recorded and discussed the results of an examination of samples of plaice and flounder from various localities. Among these localities was the Heligoland region; but Duncker had not compared the plaice of Heligoland with those of other parts of the North Sea. I have not had time to make as extensive an investigation of the matter as would be desirable. I commenced my observations at Lowestoft in September last, and continued them until the beginning of December, when I quitted the service of the Marine Biological Association. I have examined samples of plaice from the Brown Ridges, from the grounds off the Norfolk coast, from a position north-east of the Dogger Bank, and from the neighbourhood of the Eddystone Lighthouse. I have also endeavoured to acquaint myself with the complete geographical distribution of the plaice and the species most nearly allied to it, and for this purpose devoted several days to the examination of specimens in the National Collection. I have to thank Mr. G. A. Boulenger, F.R.S., for his kindness and courtesy in providing me with facilities for carrying out this part of the work in the Natural History Museum at South Kensington. I will describe first the characters of the samples of plaice from the North Sea and the South-west coast.

---

* *Wiss Meeresuntersuch.*, Neue Folge, Bd. I., Heft. 2, 1896.

I. THE VARIATIONS OBSERVED IN PLAICE FROM DIFFERENT PARTS OF THE NORTH SEA AND CHANNEL.

The method I have employed is not exactly the same as that adopted by Duncker, who followed the example set by Heincke in his papers on the varieties of herrings, in the publications of the Commission zur Untersuchung der Deutschen Meere. The first step in either method is the actual observation by measurement and counting of the principal characters in each individual fish. The characters selected by Duncker were the following:—

1. The number of vertebræ in the caudal peduncle.
2. The number of vertebræ between the abdomen and the caudal peduncle.
3. The number of abdominal vertebræ.
4. The total number of vertebræ.
5. The number of gill-rakers on the first branchial arch.
6. The number of dorsal fin-rays.
7. The number of ventral fin-rays.
8. The length of the caudal peduncle.
9. The mean height of the same.
10. The greatest height of the body without the marginal, or dorsal and ventral, fins.
11. The greatest length of the head, on the upper side.
12. The extent of spinulation in the males.

In accordance with Heincke's method Duncker divided the variations observed in each of these characters into stages, which he denoted by symbols. The object of this is, firstly, to eliminate small errors of observation; secondly, to allow the differences to become more distinct; and thirdly, to show the relations between different variations; that is, to exhibit what is known as correlation. The character of each fish is thus represented by a formula consisting of a number of symbols, and a difference between local races may be demonstrated by the fact that the most frequent formulæ are different in the two cases.

I decided to neglect the examination of the number of vertebræ altogether. The variations in these were too small to be likely to exhibit any differences between the different samples I was investigating, and so far as they existed would be sufficiently represented by the variations in the number of fin-rays and length of the caudal peduncle.

The exposure and enumeration of the vertebræ are operations that take some time, and by omitting them I was able to examine a larger number of specimens. I omitted also the mean height of the caudal peduncle, the determination of which did not appear to be susceptible of great accuracy, and I did not follow Duncker in combining together head-length and height of body. I added the examination of another character, namely, the number of the tubercles, whose prominence or flatness I also noted.

The characters I have examined are therefore the following:—

1. Maximum height of body without fins.
2. The length of the head, from the apex of the lower jaw to the end of the opercular bone, on the upper side.
3. The length of the caudal peduncle, from a line joining the ends of the marginal fins to the middle of the line of articulation of the caudal fin-rays.
4. The length of the caudal fin, from the latter point to the end of the middle rays.
5. The number of the tubercles on the head behind the eyes.
6. The number of the gill-rakers on the first branchial arch, upper side.
7. The number of the dorsal rays.
8. The number of the ventral rays.
9. The number of ciliated rays in the dorsal and ventral fins.
10. The ciliated (spinulated) scales on the head and body.
11. The maturity or immaturity of each specimen.

The measurements of lengths were made with a millimetre scale and a pair of dividers, and they were only taken to the nearest millimetre. It did not appear that greater accuracy was possible. The body of a plaice is not rigid like that of a crustacean, but any part of it may be stretched or compressed a fraction of a millimetre, so that any greater accuracy of measurement would have been apparent and not real. No such qualification applies to the enumerations of numerical characters, which are absolute, and were made with the greatest care. The lengths of parts after measurement were calculated as hundredths of the total body-length, which was measured from the apex of the lower jaw to the end of the tail. To obtain this length the fish was laid upon the measuring-rod, and the lower jaw was pushed into contact with the vertical surface of a piece of wood placed upright at one of the lines of the measure, the length at the end of the tail being then read off directly. The measure was always taken with the lower jaw just closed and not pressed. As the lengths were only taken to millimetres it seemed useless to calculate the proportions to higher fractions than hundredths of the body-length. The fish varied from about 200 to

500 mm. in length, so that ·01 of the total length varied from 2 mm. to 5 mm., but ·001 would have implied accuracy to from ·2 to ·5 mm., which was greater than the accuracy of direct measurement. Considering the great variations in the proportions with age and condition of the individual, differences between local races not exhibited in hundredths of the total length may be regarded as quite unimportant.

The direct results of the examination of the specimens and calculation of percentages are recorded in Tables A appended to this paper. The sexes are recorded separately, and the specimens given in order of total length, in order to show what variations depend upon sex or increase in size.

The comparison between the samples from different localities, in Tables B, has been made by placing side by side the actual numbers of individuals observed to have each degree of variation which was distinguished. Duncker has given tables of frequency, but they differ from mine in two respects; firstly, that he takes the larger stages of variation mentioned above, and secondly, that he has given the *percentage* of individuals, not the actual number. As the number of individuals was in my investigation rather small, and as the object was only to ascertain and compare the distribution of the variations, no advantage appeared to be gained by comparing the percentages of individuals instead of the actual numbers.

The largest number of individuals have been examined in the case of the Brown Ridges and the Norfolk coast, these being the two principal distinct regions where the sailing trawlers of Lowestoft work. From the other two regions, namely, the Eddystone grounds and the ground to the north-east of the Dogger Bank, a smaller number were obtained. All those from the Brown Ridges were examined at Lowestoft, and also the greater number of those from off the Norfolk coast: the latter include samples taken outside the Dowsing Bank, off Cromer, and off the Well Bank. An additional sample, taken fourteen miles from Cromer, was sent to me in London from Lowestoft. The Plymouth samples were sent from the Plymouth Laboratory. The remaining sample was a box sent from Billingsgate, and stated by the sender to have been caught 220 miles from Smith's Knoll, just to the north of the tail of the Dogger Bank, at a depth of 25 fathoms.

I will proceed now to the comparison of the various characters in the samples.

According to the statistical enquiries of Mr. Francis Galton and Professor Weldon the magnitude of a character which occurs with the greatest frequency nearly coincides with the arithmetical mean of all the observed magnitudes, and the frequencies of the other magnitudes are symmetrically disposed about the maximum frequency.

In my results in the majority of cases an approximation to this condition is visible; but I have not calculated the actual mean, or attempted to determine the probable error or mean error of the deviations. The question I have proposed to investigate is merely whether there are between the samples differences in the characters examined, which are sufficient to be definitely demonstrated by comparing the frequencies with which the variations occur.

The most frequent height of body in the plaice of Brown Ridges is 39, both in the males and females. In the females from the Norfolk coast it is the same, while in the males it is 38. But we cannot say therefore that the Norfolk males are narrower, for among the Brown Ridges specimens there are 16 having a body-height less than 38 per cent., and among the Norfolk coast males only 10. On the contrary, the number of specimens having heights of 40, 41, and 42, is greater in the Norfolk coast males than in those of the Brown Ridges, and this does not appear to be due to a difference of age or stage of growth. Duncker found that a considerable decrease in breadth took place between 15 cm. and 20 cm. in length, and an increase after 30 cm. But where two local races are known to differ in absolute size, like those we are now comparing, the question is whether we are comparing samples of corresponding stages and ages. Now there are rather more specimens between 20 cm. and 25 cm. in the Norfolk coast sample than in the other, and therefore more young specimens, and these should be rather narrower than the old specimens; but we have no reason to suppose that the largest specimens in the Norfolk coast sample are older than those from the Brown Ridges. On the whole, then, we must conclude that the male plaice from the Norfolk coast are broader than those from the Brown Ridges. The single male at 45 was only 20·7 cm. long. The females of the Norfolk coast are also slightly broader than those from the Brown Ridges.

It will be seen that the difference between the sexes in height of body is very slight, but what superiority there is, is on the side of the females, and this is in agreement with Duncker's results.

In the Plymouth females the body-height 38 per cent. is the most frequent, while the males appear to be broader, the maximum being at 39. On the other hand, in the plaice from north of the Dogger Bank, although there is no maximum frequency, the number of individuals being small, the much greater breadth of body is sufficiently obvious. A comparison of the lists of specimens from the Norfolk coast, and from the more northern ground which I have given, will show that the greater breadth of the more northern specimens does not depend entirely on age or size. A similar great height of body was found by Duncker in the Cattegat plaice, which exceed in this respect the plaice of the Baltic. The latter are stated to be mostly from 38 to 39 per cent. in height, like my specimens from Brown Ridges and the Norfolk coast. Now the largest specimens from the Cattegat examined by Duncker were between 39 and 40 cm. in total length; but Petersen, in the *Report of the Danish Biological Station*, 1893, records specimens up to nearly 22 inches, or 55 cm. Thus the Cattegat plaice do not appear to be very much smaller on the whole than those of the northern part of the North Sea, and we may conclude that they are similar to these. Whether they agree with them in other characters will be seen in the course of this paper.

In the last two columns I have added the figures of Plymouth and Brown Ridges to represent a southern race, and the figures of the other two localities to represent a northern, and it will be seen that though the maximum frequency still remains in both sexes of both races at 39, yet the northern race is distinctly broader.

In the second set of tables are seen the frequencies obtained by taking all individuals regardless of sex, and here also the greater breadth of the Norfolk coast specimens, and of those from north-east of the Dogger Bank, is evident.

Length of Head. The most conspicuous fact that appears from the figures referring to this character is that in all four cases the females are distinctly longer in the head than the males. This agrees with Duncker's results. Duncker also found that the length of the head decreased during the growth of the fish. Such decrease is evident in my list of the males from the Brown Ridges, where the length 20 occurs seven times among the 15 largest specimens, and only greater lengths occur among the 37 smaller. The length 19 per cent. occurs only once, and that is in the largest male from beyond the Dogger Bank. But a similar decrease is not perceptible in the females. In the Norfolk coast females the length 24 per cent. occurs eight times, twice in the largest specimens, three times in specimens between 30 and 40 cm., and three times in specimens between 20 cm. and 30 cm. The greater length of head, then, in the females of the Norfolk coast is not due to a greater proportion of young specimens in this sample.

In the samples from the Brown Ridges and the Norfolk coast the maximum frequency is in both sexes at 22, but in the case of the Norfolk coast the greater lengths are more frequent, and the shorter less frequent than in the case of the Brown Ridges. It is not, however, so obvious that the specimens from north-east of the Dogger Bank have longer heads than those of the Norfolk coast, or even than those of the Brown Ridges. If we take into consideration the small number of specimens we see that there is a slight superiority over the latter. The Plymouth specimens again, as far as we can judge from so small a sample, appear to be a little shorter in the head than those of the Brown Ridges; in the males of these only the most frequent head-length is 21, while in all the other cases the maximum is at 22. In treating the samples in two sections only, southern and northern, we see that the former are shorter in the head. When the numbers of the two sexes are combined, the Norfolk coast sample appears to have the longest head on account of the large number of females in this sample. The greater length of head in the northern plaice is evident when all the figures are combined into two columns.

Caudal Peduncle. In this character a constant difference between the sexes is not evident, but again a slight superiority in the northern samples is indicated.

Length of Caudal Fin. The caudal fin appears to be distinctly longer in the sample from the Norfolk coast than in that from the Brown Ridges, the most frequent length being 19 per cent. in the former, 18 per cent. in the latter. The Plymouth specimens, however, have rather longer tails, at least in the males, than those of the Brown Ridges, and those of the north-east of the Dogger Bank rather shorter than those of the Norfolk coast. I am inclined to think that a reduction in the relative length of the caudal fin takes place as the limit of increase in size is reached; in other words, that the fin is shortest in the oldest specimens, the caudal fin growing less than the body in adult specimens, especially when the size reached is great. Thus two of the three specimens of the Norfolk coast, in which the caudal fin is only 16 per cent. of the total length, are the two largest, 56·8 cm. and 63·0 cm. respectively. The Norfolk coast samples certainly include more young specimens than any of the others, as well as absolutely the smallest specimens examined, as is natural from the fact that the district is nearest to the shore; and in this sample the greater lengths of caudal fin are most frequent.

Number of Tubercles. This is a character which is not considered by Duncker. Numerical characters are not usually subject to change with growth in the individual, but this character may possibly change to some extent. When one or more tubercles are so flat as to be virtually obsolete, I have counted only those which were distinct, while in other cases some of the five usually present are represented by two or more separate points. The flatness or prominence of the tubercles must be considered, and it is not fully represented in the tables.

In all cases the normal number 5 is most frequent. A reduction occurs most commonly in the sample from the Norfolk coast; it does not occur in the specimens from the Brown Ridges, but is more common in the Plymouth specimens than in those from north-east of the Dogger Bank.

The description "flat," however, in reference to the tubercles, occurs frequently among the notes of examination of the specimens from beyond the Dogger Bank, and least frequently in connection with the Brown Ridges specimens. The reduction of the tubercles, which makes some of them virtually obsolete and the rest less prominent, was particularly noticed in the largest females from the Norfolk coast, especially in a sample sent me in November, and caught fourteen miles off Cromer. In many of these I thought the condition suggested that the tubercles had actually been subject to mechanical friction. In the same specimens the edges of the marginal fins were thickened and contracted, evidently in consequence of frequent abrasion and healing. We know that the ground off the Norfolk coast is very rough and stony, and that the plaice is in the habit of burying itself in the ground it lives on. The fish also must doubtless push its head under stones and into the ground to obtain its prey; so that I think it very probable that the tubercles, as well as the edges of the fins, are worn away in the plaice of this district. The ground on the Brown Ridges, on the other hand, is composed of exceedingly fine smooth sand; that beyond the Dogger Bank is rather smooth; and on the Plymouth grounds both rough and smooth occur.

Gill-rakers. In all cases the most frequent number of the anterior processes on the first branchial arch is 10, and there is not much difference in this character between the sexes or the samples from different localities. But there is seen in the females of the Norfolk coast a slight indication of an increase in the number; the numbers above 10 occur more frequently in proportion. Considering the large number of female specimens from the locality which were examined (91), this result is, I think, significant, and it is confirmed by a similar indication in the females of the most northern locality. We may infer that the number of gill-rakers increases as we proceed towards the north.

Fin-rays. The variation in the number of fin-rays is considerable, and the frequencies of the different variations are not very symmetrically distributed. The largest sample is that of the females of the Norfolk coast, and here the most frequent number in the dorsal fin is 72; but the middle frequency, which is almost as great, is 73. The most frequent number in the males is 74; but, nevertheless, it will be seen that on the whole the number of fin-rays is greater in the females than in the males in all the samples; that is to say, in the former the higher numbers occur more frequently, and the lower numbers less frequently. In the females from the Brown Ridges there are two maxima for the dorsal rays: one at 70, the other at 76. Whether this indicates a true dimorphism, like that found by Professor Weldon in the shore crabs of Naples with regard to their frontal breadth, I am not prepared to say, the number of individuals being too small. But it is clear that the females of the Brown Ridges have on the whole a slightly greater number of fin-rays than those of the Norfolk coast, and the same is true of the males. As in other cases, the Plymouth specimens seem to resemble those of the Brown Ridges; those from beyond the Dogger Bank to resemble those of the Norfolk coast, in this character. The most frequent number of anal rays in the Norfolk coast and Brown Ridges samples is 55, except in the males of the former, where it is 53 or 54. As in the case of the dorsal rays, the figures show a slight superiority in number of anal rays of the southern samples over the northern, although the difference is not in either case very important.

Spinulation of the Scales, or Ciliation. In the tables of frequencies I have employed almost the same degrees of spinulation as Duncker, but have distinguished two degrees in the spinulation of the head instead of one. The degrees are (1) on the middle rays of the dorsal and ventral fins only; (2) also on the head in front of the preopercular bone; (3) also on the operculum; (4) also on the skin of the body near the edges, in the region over the interspinous bones; (5) spinulation extended over other areas of the body. In examining the specimens I counted and recorded the number of dorsal and anal fin-rays on which spinulated scales occurred, and in the first set of tables in which the characters of each specimen are given I have added the numbers together, and given for each specimen the total number of spinulated rays. One object of this was to ascertain whether the spinulation of the scales extended on to additional rays in proportion to the degree in which it extended to other parts of the body. The result is to show that there is no exact proportion between the number of fin-rays which are spinulated and the extension of the character on other parts of the body. The fact is that scales are also present along the middle rays of the dorsal and anal fins in the females and in the young males, although, like the scales on the other parts of the body, in these cases they are not furnished with spines on their outer edges. In a female 30·7 cm. long from Plymouth I found that there were rudimentary scales on 24 of the dorsal rays and 21 of the ventral. The spinulation develops at about the time when the male becomes mature, and evidently develops very quickly, although it possibly increases with age. I obtained some male specimens of the Norfolk coast plaice from 20 cm. to 25 cm. in length on purpose to study the development of the spinulation on the scales. In a specimen 20·7 cm. long, and another of 23·8 cm., there was no trace of spines on the scales of the fin-rays, while in another 25·8 cm. long they were just developing. In most cases there are not more than two spines on each scale, and on many scales only one spine. The spine commences as a deposit of calcareous matter in the shape of a short cone, and is formed not as an outgrowth from the scale, but as a separate deposit, of which the base afterwards becomes united to the scale. The position and shape of the growing spine are shown in Fig. 1.

In the table of the frequencies of the degrees of spinulation I have omitted those specimens from the males of Norfolk coast and the Brown Ridges which were below 26 cm. in length. In the former case there were eight of these, leaving 41 to be considered; in the latter there were only two omitted, leaving 50. It will be seen that in both cases the second degree of spinulation is the most frequent, but it is equally evident that the higher degrees are somewhat more frequent in the specimens from the Norfolk coast. Now among the latter the smaller specimens must be younger and more immature than those of the same size from the Brown Ridges, and therefore the lower degrees of spinulation ought to be more frequent in the specimens from the Norfolk coast, if we consider only those which do not exceed the maximum length of those from the Brown Ridges. One specimen, however, of the three from the Norfolk coast which had no spinulation was actually mature—it was 36·5 cm. long; the other two were apparently immature, and were smaller. This shows that the development of spinulation does not always correspond exactly to the attainment of maturity, although it does so usually. In the Norfolk coast sample there are 12 specimens exceeding in size the largest of the Brown Ridges plaice; the largest of these 12 is 48·9 cm. long, the next largest is 43·2 cm. Putting aside the largest, we cannot consider the other 11 to be older than any of the

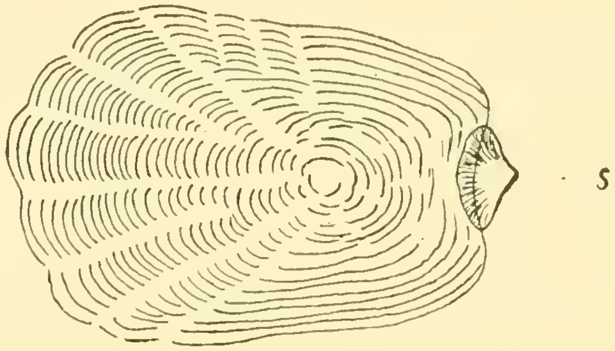


Fig. 1.

Scale of dorsal fin-ray of a plaice from the Norfolk coast, 25·8 cm. long, magnified. *S* the incipient spine at the outer edge of the scale.

specimens from the Brown Ridges, because the difference is not greater than that which I have shown to exist in the length of the smallest mature in the two cases. The largest specimen from the Norfolk coast has the fourth degree of spinulation. Taking all these facts into consideration, I conclude that on the whole the spinulation is slightly but distinctly greater in the plaice from the Norfolk coast than in those from the Brown Ridges.

In the females also there is a slightly more frequent spinulation among the specimens from the Norfolk coast than in those from the Brown Ridges. It is rare to find any trace of the condition in the females, but it is by no means exclusively confined to the oldest or largest specimens. One of the three spinulated females from the Norfolk coast was only 27·0 cm. long, and apparently immature.

The much greater development of spinulation in the plaice from beyond the Dogger Bank is very evident from the figures. But we must consider how far this may be due to the greater age of the specimens, since the locality where they were captured is in greater depth of water and much farther from the coast than the district off the Norfolk coast, or even the Brown Ridges. Now in the males of the deep-water sample there are eight specimens over 40 cm. in length, the largest being 47·3 cm. long; of these, in the smallest specimen, the degree of spinulation is 2, in the largest 5, and in the other six 4. Of the males from the Norfolk coast, six are over 40 cm. in length, and the largest is 48·9 cm. long; of these three have degree 2, one degree 3, and two only have degree 4. We have no reason to suppose that the northern specimens are older, although not larger; the presumption is the contrary. Therefore we have sufficient proof that the plaice from the more northern locality are considerably more spinulated at the same age than the Norfolk coast specimens, and *a fortiori* than those of the Brown Ridges. There is evidence that the development of spinulation increases with age; but enough evidence has been here produced to show that the difference between my samples from different localities is not due to differences of age.

It may be pointed out as worthy of note that in the two females in which spinulation occurs among the specimens from beyond the Dogger Bank, it is present on the cheek, and almost entirely absent from the fins.

The males from Plymouth appear to be rather more spinulated than those from the Brown Ridges; but it may be mentioned that in the specimen which is recorded as having degree 4, the spinulation of the interspinous regions was only just perceptible.

Recapitulation. The investigation shows that although the number of individuals examined is not so large as it should be, yet there are distinct differences in structural characters between the samples, especially between those of the Norfolk coast and the Brown Ridges, which would almost certainly be confirmed by examination of a larger number of specimens.

Omitting the tubercles and the length of the caudal peduncle, in which the indications are not very distinct, I find distinct differences in the following characters: Height of body, length of head, length of caudal fin, spinulation of scales, number of gill-rakers, number of fin-rays. The length of the caudal fin decreases apparently with age, and it is not very evident that it is a permanent characteristic of the different local forms. We have then left three characters of proportion and two of number. The first three characters all vary with age, the latter two do not change in the individual.

The change in the height of the body with age does not appear to be very constant or important in my samples; the height is distinctly greater in the northern samples than in the southern. The difference between the sexes is slight.

The length of head is a marked sexual character, being greater in the females; it decreases as age advances, but within the limits of size of my specimens the decrease is not obvious in the females, and not very important in the males. The length of head is a little greater in the northern samples.

The spinulation of the scales is a character, with few exceptions, confined to mature males, and forms the most conspicuous local peculiarity. There is no important difference in this character between the plaice of Plymouth and those of the Brown Ridges; but on the Norfolk coast, and still more beyond the Dogger Bank, it is much more developed than on the Brown Ridges.

The number of fin-rays is slightly greater in the females, and is somewhat less in the northern samples than in the southern.

The gill-rakers, on the contrary, are slightly increased in the northern samples as compared with the southern.

II. Comparison of the Local Forms Examined with those of other Regions.

Duncker examined 35 males and 45 females caught in the neighbourhood of Heligoland. The males were from 13·4 cm. to 28·9 cm. in length, the females from 19·3 cm. to 32·6 cm. Now I have shown in a previous paper that no plaice from this district were mature below 11 in., or very nearly 28 cm., in two samples which I examined, containing together 307 specimens. It is not surprising, therefore, that in Duncker's specimens the degree of spinulation was much lower than in the samples described above from the Norfolk coast, and even from the Brown Ridges. Duncker's male specimens from Heligoland must have been all, or nearly all, immature. It will be seen from my list of Norfolk coast specimens that spinulation often commences on the fin-rays before maturity, and this accounts for the fact that the first stage of the character occurs in a considerable proportion of Duncker's specimens. The smallest in which it occurs is 20·6 cm. long; the largest in which there is no spinulation at all is 26·6 cm. long. In my Norfolk coast samples the smallest specimen in which spinulation occurs is 23·5 cm. long, and only one smaller than this was examined, while the largest in which it was absent is 36·5 cm. long. Degree 2 occurs in Duncker's specimens, in one specimen 24·5 cm. long, and one 26·7 cm. long, while in the Norfolk coast specimens the smallest in which this degree occurs is 27·3 cm. long. It is not possible then to conclude from Duncker's specimens whether in the race to which they belong spinulation is much developed or little. There is nothing to contradict the probability that they belong to a race as strongly spinulated in the adult males as the Norfolk coast form or that from beyond the Dogger, and we certainly have no evidence at present that they are less spinulated than those of the Brown Ridges. Duncker unfortunately overlooked the question of the age and maturity of his samples.

Duncker divides the height of the body into only two degrees, and combines it in his formulæ with the length of the head, and I can therefore only attempt to make a comparison from his descriptive remarks. He says that the height exceeds 38 per cent. in the Heligoland plaice but seldom, and it would seem from this that these plaice are rather narrower than those from the Norfolk coast of the same size, and perhaps than those of the Brown Ridges; but the comparison, under the circumstances, is not worth much. Seventy-two per cent. of the Heligoland specimens have a length of head over 24 per cent., and this would seem to show that these plaice were much longer in the head than any of my North Sea samples. But with regard to both these characters it must be remembered that the proportion of smaller specimens is much higher than in my samples, even when I consider only those of my specimens which are below the maxima sizes of Duncker's; and I conclude, therefore, that the head is much longer in the younger specimens. Indeed Duncker himself mentions the fact, stating that the 21 smaller females from Heligoland have a mean head-length of 24·9 per cent., and the 24 larger, above 23·6 cm. in length, a mean of only 23·7 per cent.

No comparison then is possible except in the characters which do not vary with age, namely, the numbers of fin-rays and gill rakers;

and here Duncker does not give details, but simply states that the anal rays are mostly 51 to 55, the dorsal 66 to 80, and the gill-rakers mostly 10 or 11.

In describing some specimens from the Baltic in this Journal* Mr. Holt referred to two spinulated specimens of the plaice, one from the south coast of Iceland, and one from the Great Fisher Bank in the North Sea. These specimens were among the collections left by Mr. Holt at Cleethorpes which came under my charge. I have examined them, and recorded their characters in the tabular lists appended to this paper. They are both males of large size, and except in the greater size of the Iceland specimen do not differ much from the largest of the males I have examined from beyond the Dogger Bank. In both specimens, as often occurs in the higher degrees of spinulation, this character is developed slightly on the head and body on the lower side. It never occurs on the fin-rays of the lower side, because there the scales are virtually obsolete. In the Iceland specimen the scales are spinulated all over the upper side of the body except below the pectoral fin, and also very slightly on the head and interspinous regions on the lower side. In the Fisher Bank specimen the spinulation extends all over both sides, also with the same exception, but is much weaker on the lower side than on the upper.

We have next to consider the plaice of the Baltic, samples of which are described by Duncker. Some of the specimens mentioned by Holt in the paper above cited came into my hands, and their characters are detailed in the tabular lists. The plaice of the Cattegat occupy geographically a somewhat intermediate position, and we may examine their characteristics before referring to the fish of the Baltic proper. Duncker remarks of the Cattegat plaice that they resemble those of Heligoland in all other respects, but differ in their enormous height of body and the shortness of the head. This is exactly what might be expected when we know that Duncker's sample from Heligoland consisted chiefly of very young and small specimens of a large-sized race. The males of Duncker's Cattegat sample were from 29·5 to 39·4 cm. in total length, and 10 in number; of females there were 30 specimens 28·0 to 38·6 cm. in length. They were thus nearly all larger than the largest of the Heligoland specimens. Four of the 10 males had no spinulation, two had degree 2, and the rest degree 1. One of the specimens without spinulation was 39·4 cm. long, one 35·0 cm., one 34·1 cm., and one 29·5 cm. According to Petersen's records† some male plaice are immature in the Cattegat at 32·5 cm., if not even at a larger size. But in none of my samples is a male specimen so large as 39·4 cm. entirely without spinulation. I find it difficult to believe

---

[*] Vol. iii. p. 198.

[†] *Report of the Danish Biological Station*, iv., for 1893.

that plaice in the Cattegat are less spinulated when mature than those of the northern part of the North Sea, and think it probable that if a larger number of mature specimens from the former locality were examined they would be found to exhibit as great a development of spinulation. My specimens from beyond the Dogger Bank, being taken in deep water far from land, would naturally include few immature specimens, and male specimens in that condition even 35 cm. in length might occur nearer shore. It must be pointed out that in my specimens from beyond the Dogger Bank degree 4 of spinulation only occurs in specimens over 40 cm. in length, and we know from Petersen that male specimens above that length occur in the Cattegat, although Duncker did not obtain any. There is nothing in the results of Duncker concerning the numerical characters to distinguish the Cattegat plaice from those of the northern part of the North Sea examined by me.

Duncker examined 34 males and 48 females from the Western Baltic, taken in the neighbourhood of Niendorf and Kiel. The males were from 22·6 to 29·7 cm. long, the females from 22·3 to 31·2 cm. long (from 9 in. to little over 12 in.). We know from Holt's evidence that plaice of the Western Baltic at these sizes are all, or nearly all, sexually mature. The spinulation varies from degrees 2 to 5 according to my notation, and it is certain that it is more strongly developed than in the most spinulated of my samples, degree 1 occurring not infrequently in the females.

The height of the body, on the average 38 to 39 per cent. according to Duncker, seems to be no greater than in the Norfolk coast plaice, and scarcely so great as in the specimens from beyond the Dogger Bank. The length of the head is a little greater than in the northern part of the North Sea.

In the numerical characters there is a marked reduction: the dorsal rays rarely exceed 70, though instances up to 75 and one of 78 occur. The ventral have a maximum of 60, but are mostly from 46 to 55. In this respect the form approximates to the character of the flounder. The number of the gill-rakers, however, is not greater than in North Sea plaice, but is on the contrary rather less, the number 12 not being exceeded, while in the Cattegat plaice the range of variation extends to 13, as in my specimens from the North Sea.

The caudal peduncle, reaching sometimes 9 per cent., seems to be rather larger than in the North Sea.

Duncker describes four males and seven females from Greifswald, a place on the coast opposite the island of Rügen, and little more than 100 miles east of Kiel. On the evidence of these few specimens he concludes that the Greifswald plaice are on the whole different from those of the neighbourhood of Kiel, and approximate in several characters more to those of the North Sea, although it might be expected that, the locality being farther inwards in the Baltic, they would be more different from the plaice of the North Sea. I fail, however, to find in Duncker's description any differences to which such importance can be attributed, especially when the small number of specimens is considered. The four males are all small and young, 19·6 to 22·6 cm., and this would partly account for the slightly lower height of body and greater length of head which Duncker mentions. The number of gill-rakers reaches 13, but I fail to see any difference in the number of fin-rays. The degree of ciliation was 2 in all four male specimens, which is in accordance with their small size.

We see then that as far as the small amount of evidence at our disposal goes, the Baltic plaice are modified in the same direction as northern forms in the North Sea with regard to reduction of fin-rays and increase of spinulation, and to a much greater degree, while with regard to other characters, branchial rays, height of body and length of head, no very distinct differences are exhibited. In accordance with the reduction of the dorsal and ventral fins, the caudal peduncle is a little longer in the Baltic. It is interesting to notice that as we proceed northwards in the North Sea and Atlantic these modifications are associated with a great increase in total size, while in the Baltic there is an equally conspicuous decrease in size. This proves that the modifications are independent of the rate of growth, and therefore presumably of the amount of available food.

III. THE RELATIONS BETWEEN LOCAL VARIATIONS AND SPECIFIC CHARACTERS IN THE PLAICE AND ALLIED SPECIES.

The plaice and flounder are certainly very closely allied, and there is a third form which also differs but slightly from them. This third form is the *Pleuronectes glacialis* of Pallas. To study the relations of these three forms to one another we must take a general survey of all that is known concerning their whole distribution, and their variations in different parts of their habitats. The question has previously been discussed by Professor Smitt in his edition of the *Scandinavian Fishes* of Fries and Ekström, 1893, and by Duncker in the paper frequently cited above; but I have endeavoured, by examining additional evidence, to carry the investigation somewhat further.

Pleuronectes platessa. Southwards on the European coast the plaice seems to extend into the Mediterranean, although I have not been able to discover any very definite or detailed account of specimens from that sea. Smitt mentions its existence there, and Jordan and

Goss[*] state that in the Museum of Comparative Zoology at Cambridge, Mass., there are a number of specimens from Trieste. Northwards the species extends to the White Sea. The evidence of this is that Smitt (*loc. cit.* p. 395) mentions a young plaice from Archangel which agrees with the form described by Pallas from Alaska and Kamtchatka under the name *Pl. quadrituberculatus,* and by Steindachner under the name *Pl. Pallasii.* Smitt regards these names as synonyms of *Pl. platessa.* I do not admit the synonymy, and shall discuss the matter presently; but we may take it that the plaice extends to the White Sea. We have seen that it is abundant on the south coast of Iceland, and extends into the Baltic as far as Greifswald. But the plaice is not mentioned as occurring on the coast of Greenland, and is certainly absent from the east coast of North America. In the Pacific, however, forms which must be regarded as local varieties of the plaice, or very closely similar to it, reappear, and I will here give the history of these forms so far as it is known. The following is a list of the names under which the specimens have been described or mentioned:—

Pleuronectes quadrituberculatus, Pallas, Zoogr. Rosso-Asiat. iii. 423, 1811. Bean, Proc. U.S. Nat. Mus. 1881. Jordan and Gilbert, Synopsis Fish. N.A. 1882.

Parophrys quadrituberculatus, Günther, Cat. Fish. Brit. Mus. iv. p. 456 (copied).

Pleuronectes Pallasii, Steindachner, Ichth. Beitr., S.B., k. Akad. d. Wiss. Wien, lxxx. 1880.

Platessa quadrituberculata, Jordan and Goss, Flounders and Soles of Am. and Eur. Rep. U.S. Fish. Com. for 1886, pub. 1889.

The original description of *quadrituberculatus* by Pallas is as follows:—

Longitudo (11″ 4‴) fere pedalis, latitudo summa cum pinnis 5″ 11‴ sine pinnis 4″. Forma Flesi. Caput a latere oculato, fusco nigricante, tuberculis quatuor osseis, conicis obtusis prominentissimis, serie lineae laterali continua, quorum duo approximata anterius, tertium orbitae superioris postico margini contiguum, quartum maximum sinui branchiali adsidet. Linea lateralis in utroque latere a sinu branchiali levissime descendens, dehinc media rectissima speciem catenulae referens. Corpus glaberrimum, squamis subdistinctis obsoletissimis, cauda evidentius squamosa usque in radiorum intervalla. Opercula angulata. Pinnae pectorales rad. 11 subacutae; ventrales falcatae, rad. 6. P. dorsi ab orbitis incipiens rad. 70. P. ani pollicari a ventralibus distantia, rad. 51. Spina subcutanea ad anum. P. caudae rotundata, radiis 18 robustis bifidis.

---

[*] "Flounders and Soles of America and Europe." *Report of U.S. Fish Commission for* 1886.

Now there is one point in this description which shows that the fish described was not a plaice at all. The four tubercles are not all behind the eyes, but only the third and fourth. Jordan and Goss describe their specimen as having about five tubercles above the operculum, and D. 68, A. 50. Bean gives no description, but states that his specimen was obtained at Kodiak; Jordan and Goss' specimen was also collected at Kodiak, and it is not clear whether it was the same specimen or whether there were two. Kodiak is a large island off the south coast of Alaska.

In the British Museum collection there is a single specimen identified as the *quadrituberculatus* of Pallas, and collected by the U.S. Fish Com. steamer *Albatross.* The identification is evidently that of the American naturalists, and the specimen leaves no doubt as to what were the characters of the fish so identified. The specimen was taken at Herendeen Bay, a bay on the north side of the Alaska Peninsula in 56° north latitude and 161° west longitude. The characters of the specimen are given in the tables below, and it will be seen that they are similar to those of a plaice. The body is rather broad and the head long, but in these respects the fish does not differ from the plaice of the North Sea to any important extent, and it must be remembered that we can make no very minute comparison between spirit specimens and fresh specimens. The tubercles on the head are, however, peculiar, and have a character which has not been observed in any Atlantic plaice; they are remarkably prominent, regularly conical, and uniform in size. In number and position they are like the tubercles of the plaice. The scales are like those of the plaice, cycloid and reduced so that they do not overlap. The lateral line is slightly elevated above the pectoral fin, but otherwise straight as in the plaice. The specimen is male, and the scales on the fin-rays are spinulated as in the majority of male plaice. The teeth seem to be rather smaller than in the North Sea plaice.

We find then that in the North Pacific, about the shores of Kodiak and the Alaska Peninsula, there is a local variety of the plaice, of which only a few specimens have been obtained, and that this form has been erroneously identified with the *Pl. quadrituberculatus* of Pallas. The depth of water at which it was taken is not stated.

The only other record we have of a plaice-like fish in the North Pacific is Steindachner's account of *Pl. Pallasii.* The specimens so named came from Kamtchatka. The characters described are five depressed bony tubercles with blunt outer edges in a horizontal row between the eye and the lateral line. Dorsal rays, 63–68; anal, 48–53; all the fin-rays scaleless; scales small, rounded. A figure is given showing the tubercles more rounded and less prominent than in the British Museum specimen.

South of Alaska and Kamtchatka we have no evidence that the

Pacific form of the plaice exists. The flat-fishes of California and the west coast of America generally have been attentively studied by American zoologists, and are captured regularly for the market; but no specimens of this form have been noticed except the above, nor have any been discovered in Japan. The plaice-like form again is not known at present to extend further north than Herendeen Bay. Flat-fish have been collected at more northern places on the west coast of Alaska, but specimens of this form were not among them. It appears, therefore, that the species in the Pacific does not extend so far north or so far southwards as in the Atlantic; but, on the other hand, it is found on the west shores as well as on the east, whereas on the west side of the Atlantic it is absent.

Pleuronectes glacialis. Now to the northward, where the plaice disappears, the northern species, *glacialis*, is found in its stead, and this species occurs along all the northern coasts of Europe and America, and on the east coast of America. It presents local variations, and has been described under various names, but there is no doubt that it constitutes a single species, which in many respects is closely allied to the plaice. The following are the principal synonyms and references :—

Pleuronectes glacialis, Pallas, Zoogr. Rosso-Asiatica, iii. p. 424.

Pleuronectes cicatricosus, Pallas, *ibid.*

Pl. glacialis, Richardson, Voy. *H.M.S. Herald*, p. 166 (1852). Bean, Proc. U.S. Nat. Mus. 1881, p. 241 (Kotzebue Sound, Northern Alaska). Jordan and Gilbert, Synopsis Fish. N.A. Smitt, Scandinavian Fishes, 1893.

Platessa dvinensis, Lilljeborg, Svensk Vet. Akad. Handl, 1850.

Platessa glabra, Storer, Proc. Boston Soc. Nat. Hist. 1843, p. 130.

Liopsetta glabra, Gill, Proc. Acad. Nat. Sci. Philad. 1864.

Euchalarodus Putnami, Gill, Proc. Acad. Nat. Sci. Phil. 1864, p. 216.

Pleuronectes glaber, Goode and Bean, Proc. U.S. Nat. Mus. 1878, p. 347. Bean, *ibid*, p. 345.

Pleuronectes Franklinii, Günther, Cat. Fish. Brit. Mus. iv. 1862, p. 442.

Pallas first described *P. glacialis* in 1773, in his account of his journeys through various provinces of Russia; and in his larger work, published in 1811, repeated the description with but little modification. His specimens were taken in the Kara Sea and at the mouth of the river Obi. The chief characters given are the absence of spiny tubercles like those of the flounder; the ridge behind the eyes rough, but not divided into tubercles; the middle rays of the fins on the coloured side roughened with very minute spines; dorsal rays, 56; anal, 39. The upper side is also *squamulis asperis granulatum*, which probably means that the upper side was spinulated all over.

According to Pallas' description *P. cicatricosus* differs but little from *glacialis.* The specimens were collected in the sea between Kamtchatka and America. It is said to be more oblong, the length being three times the breadth without the fins. There is a rough osseous ridge behind the eyes. On the upper side the scales are far apart and scarcely projecting, except that every third or fifth over all the body and operculum has projecting setae on its margin; the middle fin-rays are also roughened with slight projecting points. Length of the specimen was $8\frac{7}{12}$ inches, the breadth $2\frac{10}{12}$ inches; the number of dorsal rays 59, anal 36. It is clear that the two forms thus described belong to the same species, and it is difficult to decide which was the more spinulated of the two.

Richardson states that he identified as the *P. glacialis* of Pallas a flounder taken in Bathurst's Inlet, which is on the north coast of North America. He afterwards obtained two specimens from the same region from Dr. Rae. They had all the characters described by Pallas, except the roughness of the middle rays of the dorsal and ventral fins. Richardson suggests for the first time that this may be a sexual peculiarity. He states that the parietal and suprascapular space—in other words, the post-ocular ridge—is divided into elevated granular surfaces; the scales are small and without spinules, except along the bases of the dorsal and ventral fins on the upper side. The length was 7·5 inches; the dorsal rays 58, the ventral 43.

In the British Museum collection there are two specimens identified with Richardson's species, which Dr. Günther named *Franklinii,* considering it distinct from *glacialis.* One of these is 22·8 cm. long (9 inches), and according to the label came from Dr. Rae's collection. It has evidently been dried, and is moth-eaten; but the spinulated scales could be felt both on the fin-rays and on the body. The other specimen has also been dried, and was too hard and stiff for detailed examination; but this also has some spinulated scales on the fin-rays and the edge of the body. This specimen was labelled, "From the Haslar collection." Probably one of these specimens, or both, were those examined by Richardson, whose description of the spinulation in such case was incorrect. They are certainly of the same species as the *glacialis* and *cicatricosus* of Pallas.

The first description of specimens of the same species on the east coast of North America is that of Storer, in 1843, who gives it the name *Platessa glabra.* He says the body is perfectly smooth, and mentions no spinulated scales on the fins. But the number of the fin-rays (D. 54, A. 39), and the character of the post-ocular ridge (naked and rough, continued back to the superior angle of the operculum, where it is much larger, and terminates in an obtuse point), show that the fish in question resembled *glacialis*. The specimens were taken in Boston harbour.

In 1864 Gill gave the name *Liopsetta glabra* to Storer's species, and described a new species under the name *Euchalarodus Putnami*. The description summarised is as follows: D. 55–58, A. 39–40. Two specimens examined, obtained at Salem, Mass. Scales minute, distinct, immersed, each one on the coloured side with several slender teeth behind, directed outwards; on the light side of the body smooth or uniciliate. Lateral line straight. Head with an osseous ridge continued backwards, where it is expanded and separated from an oblique bony tubercle on the scapula. The name was given from the teeth, which were in a single series and movable.

In 1878 Tarleton H. Bean pointed out that the movable teeth and certain other minute characters, described by Gill in *Euchalarodus*, occurred also in *P. glabra*, and in the plaice, the teeth being movable in mature specimens in the breeding season; and that *Euchalarodus Putnami* was in fact the male of *Liopsetta glabra*, differing from it only in having more of the scales ciliated. The largest female in the gravid condition was 13½ inches long. In the *Review of Flounders and Soles*, 1889, Jordan and Goss confirm Bean's conclusions, and state that they see no difference by which *Liopsetta glabra* can be separated from *P. glacialis*. Specimens have been taken from Providence, Rhode Island, to Labrador, so that the southern limit of the species is 41° north latitude.

Specimens identified as the *P. glacialis* or *cicatricosus* of Pallas have been taken in recent years by the U.S. Fishery steamer *Albatross*, on the west coast of Alaska, north of the Alaska Peninsula. The species is recorded by Bean as taken in Kotzebue Sound, but he gives no description; the same specimens, however, are briefly described by Jordan and Gilbert in their *Synopsis of the Fishes of North America*. It is there stated that the dorsal rays are 56, the anal 42 in number; that the scales are minute, imbedded, ctenoid in the males, smooth in the females. Now, the specimen in Bean's catalogue is numbered 27,947, and this very specimen, bearing the same number and labelled from Kotzebue Sound, is now in the British Museum, received from the Smithsonian Institution. I examined it myself, and have recorded its characters in the lists below. It is a female, and yet is strongly ciliated on the fins and all over the body on the upper side, and only a little less on the lower side. On the coast of Alaska then the females are not without spinulation. In Jordan and Goss' *Flounders and Soles* a female of the same form from Kotzebue Sound is figured, and appears to be the same specimen which I have examined; but the number is quoted as 27,497, probably a mere clerical error.

There are two other specimens from Alaska in the British Museum, collected by the *Albatross* in the Nushagak River, and obtained from the U.S. Fish Commission. These also I have examined, and have recorded their characters below. Both are females, and immature; the smaller is ciliated on the fins, head, and central region of the upper side, but not on the interspinous regions; on the lower side it is also ciliated in the central region. The larger is ciliated all over the upper side, except the region covered by the pectoral, but not on the lower side.

Lilljeborg's specimens came from the mouth of the river Dwina, at Archangel, from which place Smitt also obtained specimens. Smitt considers Lilljeborg's species identical with Pallas' *cicatricosus*, but thinks that there are important differences between this and *glacialis*. He says that Pallas based his distinction on the deeper form of the body, and greater closeness of the scales in *glacialis*. The difference reappears, though modified by age and sex, between the specimens brought by Nordenskiöld from the north coast of Siberia, east of the Kara Sea, and the specimens brought from the White Sea. The specimens of the east coast of the United States, according to Smitt, also belong to *cicatricosus*. The narrower form, with fewer or smaller scales, therefore, according to Smitt, occurs in the White Sea, on the east coast of America, and in the Behring Sea; while the broader form extends along the Arctic shores of America and of Siberia; the *glacialis* is a purely Arctic form, while *cicatricosus* lives in a milder climate.

The evidence I have been able to examine does not enable me to test Smitt's conclusions with regard to the breadth of body or length of head very completely. I can only point out that the three specimens from the coast of Alaska, one of which at 18·3 cm. was mature, agree fairly closely with the proportions given by Smitt for *cicatricosus*, and at the same time are not markedly narrower or longer in the head than many of the female plaice from the northern part of the North Sea. The male *glacialis* examined by Smitt were longer than the *cicatricosus*, all females, which he examined, and may have been older, which would to some extent account for their greater breadth and shorter heads. Smitt does not discuss the spinulation of the scales, and does not even mention that this is on the east coast of America a sexual character. In the two specimens from the north coast of North America which I have examined, as far as can be judged from their unsatisfactory condition, the spinulation is not greater than in male plaice from the North Sea, but their sex is unknown. The three specimens from the coast of Alaska are all females, and more spinulated than most of the male plaice from beyond the Dogger Bank.

In these specimens of *glacialis*, therefore, spinulation is undoubtedly more developed than in the most spinulated plaice, even than in those of the Baltic. On the other hand, the descriptions of the American naturalists do not tend to show that the forms named by them *Liopsetta Putnami* and *glabra* are more spinulated than the plaice of the Baltic. It is clear, however, that all the local forms of *glacialis* differ very distinctly from the plaice in the smaller number of fin-rays and the character of the post-ocular ridge, which is granulated, terminating posteriorly in a pear-shaped elevation of the skull-bone, succeeded by a slight elevation of the post-temporal bone. These two elevations correspond to the two posterior tubercles of the plaice, but are not prominent enough to be called tubercles.

We have seen that in the White Sea both plaice and *glacialis* occur; but this is the limit of the plaice eastwards and of *glacialis* westwards. The two species similarly succeed one another on the coast of Alaska, the northern limit of the plaice being the northern shore of the Alaskan Peninsula, which also forms the southern limit of *glacialis*. *Glacialis* therefore is strictly a geographical representative of the plaice. So far as we know it is, like the plaice, a marine form, not ascending rivers higher than their mouths. There are remarkable and interesting differences in the limits between the two species in different parts of the world, which are found on examination to correspond very closely to differences of temperature depending on ocean currents. In a map of the world by John Bartholomew the seas closed by ice in winter in the north are distinguished, and the distribution of the species *glacialis* corresponds almost exactly to the area of these seas. Owing to the north-eastern trend of the coast of Scandinavia the Gulf Stream, or north-easterly warm current in the Atlantic, travels far to the north and east, producing an ice-free sea as far as the entrance of the White Sea. Thus the plaice extends on the east side of the Atlantic beyond the North Cape, latitude about 72°, while on the east side of the Pacific its northern limit is about 56°. The westward projection of Alaska stops the north-easterly progress of the warm current in the Pacific, so that Behring Sea is closed by ice in winter, and here we have the form *glacialis*. Again, the open warmer sea in the Atlantic embraces the south coast of Iceland, where the plaice is not only abundant, but reaches its maximum size; while the glacial sea extends along the coasts of Greenland, down the west coast of America to Nova Scotia. The southerly cold current, known as the Labrador current, passes down from the north along the coast of Labrador and the east coast of North America, and this fact corresponds to the southerly extension of the *glacialis* form to Cape Cod, and the entire absence of the plaice. It appears that *glacialis* is taken on the coast of the United States chiefly, if not exclusively, in winter; and we may conclude that the low temperature of the water in winter excludes the plaice, while the high summer temperature prevents the extension of *glacialis* further to the south.

Pleuronectes flesus. We have next to consider the flounder, which is distinguished from the other two species most conspicuously by the character of the scales, many of which are more reduced than in the plaice, while others on particular parts of the body have taken on a peculiar development, and have been enlarged into prominent thorny tubercles. These tubercles are most constantly present in a single row along the bases of the dorsal and ventral fins, and are also usually present on the head and about the lateral line, while in certain forms they are developed over nearly the whole of the skin of the upper side.

The species occurs on the east side of the Atlantic all along the coasts of Europe—from the White Sea on the north to the Black Sea at the extremity of the Mediterranean. At different regions within these limits it exhibits local variations. Duncker examined samples from various parts of the Baltic and from the North Sea. In criticising his results we must take into account the fact that the flounder is essentially an estuarine fish, often ascending rivers into fresh water, and only descending to the sea in order to spawn.

In the Baltic the flounder extends much further than the plaice, and generally exhibits a much greater development of tubercles than on the coasts of the North Sea. Duncker examined samples from Königsberg, Greifswald, Niendorf, and Kiel. From Königsberg he had 20 males and 8 females; the males from 19·0 cm. to 28·2 cm. in length, the females from 23·3 to 28·2 cm. They were remarkable for their very rough squamation, great height of body, very short heads, and conspicuous red spots, approximating to the coloration of the plaice. There were crowded small tubercles over the whole of the upper side, on the blind side at least along the lateral line, on the abdomen, and on the interspinous region. The average height of body was 39·9 per cent. in the males, 41·1 per cent. in the females. The length of head was 22·3 per cent., and also less in the males. The number of fin-rays was higher than in other Baltic samples, the mean of the dorsal being 58·1, of the ventral 40·7. The number of gill-rakers was 11–18.

The Greifswald sample consisted of 14 males, 15 females; the males in length 16·5 cm. to 26·0 cm., the females 15·8 cm. to 34·6 cm. In these the squamation was less rough; the height of body less, 37·8 per cent. on the average; the head longer. It seems to me all these differences are sufficiently explained by the greater proportion of younger and smaller specimens. The mean numbers of the dorsal and ventral rays was a little lower, but in such a small number of specimens the difference does not seem of great importance.

From Niendorf and Kiel there were 26 males, 30 females; the length of the males was 20·1 cm. to 38·5 cm., of the females 20·8 cm. to 30·6 cm. According to Duncker the squamation and coloration are intermediate between the Greifswald and Königsberg forms. The Niendorf males were narrow, and these were few in number and of large size; the length of head slightly greater than in the Königsberg sample, a fact very probably due to the greater proportion of females. The mean of the numbers of dorsal fin-rays was only a little over 56, that of the ventral the same as in the Greifswald sample.

Duncker's North Sea specimens were collected near Heligoland, therefore in the sea; at Cuxhaven at the mouth of the Elbe; and at Hamburg. Considering the migratory habits of the species, it is obvious that these must be considered as belonging to one region, and Duncker admits that they are difficult to distinguish. The Heligoland specimens are stated to have been obtained in July and August, and it is surprising that flounders should be found abundantly in the sea at that time of the year. But perhaps the fact is explained by the shallowness of the water, and the proximity of the two large rivers Elbe and Weser. We find, however, as might be expected, that the Heligoland specimens are the largest and doubtless the oldest. The numbers and sizes are:—

Heligoland . .	15 males,	23·0 cm. to 31·5 cm.
	29 females,	23·8 cm. to 42·1 cm.
Cuxhaven . .	18 males,	22·4 cm. to 28·0 cm.
	7 females,	22·5 cm. to 26·1 cm.
Hamburg. . .	14 males,	15·1 cm. to 27·8 cm.
	13 females,	22·2 cm. to 27·8 cm.

In these North Sea flounders the rough tubercles are limited to the bases of the fins and the lateral line, while the scales on the rest of the body are smooth and cycloid; the tubercles occur chiefly at the anterior part of the lateral line, and in the middle region of the bases of the fins. The number of gill-rakers is on the average two or three higher than in the Baltic (15 to 22). The fin-rays are more numerous. The body is narrower; but in the length of head no constant difference was evident.

I cannot altogether agree with Duncker in his views with regard to the comparison between the variations of the plaice and flounder in the North Sea and Baltic. He considers that the two forms approach one another to some extent in the Baltic more than they do in the North Sea. In the two cases we find a similar modification in the greater roughness of the scales, in the greater breadth of the body, and the reduction in the number of fin-rays. The number of gill-rakers is higher in the flounder than in the plaice, and is reduced in the Baltic; in this respect the modification does reduce the difference between the species, and the difference in the coloration is also reduced in the Baltic. The length of the caudal peduncle in the flounder is reduced in the Baltic, while in the plaice it is somewhat increased. The three modifications which are in the same direction are those which take place in passing from south to north; and it is a fact that the Baltic is colder than the North Sea. On the other hand, it seems to me probable that as the Baltic is fresher than the North Sea the flounder there may live less in the rivers, and therefore, on the whole, in salter water, while the plaice lives in fresher, and that this may have something to do with the brighter red spots in the flounder in the Baltic.

The flounder in the Mediterranean has been described under different names in the belief that it formed distinct species. The synonyms, or names given to these local forms, are:—

Pleuronectes luscus, Pallas, Zoogr. Rosso-Asiat. iii. p. 427. 1811 (Black Sea).

Platessa glabra, Rathke, Fauna der Krym., p. 352. 1837 (Crimea).

Platessa passer, Bonaparte, Fauna Italica, Pesc. 1838–40.

Pleuronectes italicus, Günther, Cat. Fish. Brit. Mus. iv. 1862 (Dalmatia).

I have not taken the trouble to go through the descriptions given by the authors cited, but have examined the specimens in the British Museum, details of whose characters are given in the lists below. The chief peculiarity of *italicus*, according to Günther's description, is that the lateral line is smooth, not furnished with thorny tubercles. In the smallest of the three specimens from Dalmatia there were no tubercles on the lateral line, and no spinules on the scales on the middle fin-rays of the dorsal and ventral fins. In the next specimen in order of size there were spinules on 22 of the dorsal and ventral rays, no tubercles on the lateral line or on the head. In the third specimen two tubercles were found at the anterior end of the lateral line, but only one spinule was detected on the dorsal fin, none on the ventral. Spinules on the fins are not present in the North Sea flounders. The number of the fin-rays is not greater than in the North Sea flounders, but is as great, and therefore greater than in the flounders of the Baltic. The height of body also resembles that of the North Sea specimens, while the length of the caudal peduncle is as short as in the Baltic. The length of head shows nothing remarkable.

Of the local form described as *luscus* there were seven specimens in the British Museum: four from Constantinople and the Bosphorus, three from the Black Sea. In all these there were a number of tubercles along the front part of the lateral line, but these were not very abundant or very prominent. The spinules on the fin-rays were also more numerous and more regular. The fin-rays are scarcely different from those of the Dalmatia form, but the body is higher and the head apparently a little longer; these, however, are differences of age, the body being higher in the larger specimens, the head longer in the smaller. In the Black Sea specimens, as in those from Dalmatia, the tubercles along the bases of the fins are present, more developed in the former. Again, we find here that the greater development of tubercles corresponds to a colder climate; the Black Sea is considerably colder, at least in winter, than the Adriatic. The presence of spinulated scales on the fin-rays, as in the plaice, is remarkable.

On the northern coast of the eastern hemisphere the flounder is not known to occur further east than the White Sea. Smitt states that Lieut. Sandeberg brought specimens from the White Sea in which the body was entirely smooth, with the exception of the spinous tubercles at the bases of the fin-rays, and a few on the head and near the lateral line. They were described as a distinct species under the name *Pleuronectes Bogdanovii;* but quite similar forms may, according to Smitt, be found in the Baltic. These were apparently individual variations, and it is not clear whether or not the flounder on the whole is as strongly spinous in the White Sea as in the Baltic.

The flounder is not included in Lütken's *Fishes of Greenland*, and is not mentioned as occurring on the north-east coast of North America. Yet there is a form, scarcely distinct as a species, in the Pacific, remarkable chiefly for the extensive development of spiny tubercles, but in the character of these tubercles, and in other respects, very closely similar to the European flounder. The chief difference is, that according to the descriptions of Jordan and Goss there are no cycloid scales in the Pacific form, to which they actually give a distinct generic name, *Platichthys stellatus.* This form extends from Point Conception on the coast of California, latitude 34°, to Coronation Gulf on the Arctic coast of America, which is north of latitude 70°, and not very far west of Hudson's Bay. It is difficult to understand why the flounder-like form should be absent on the intervening coasts, or in the intervening rivers, between the north-west coast of America and the coast of Europe. On the Asiatic side of the Pacific the form *stellatus* extends southwards to Saghalien, and indeed from the descriptions appears to be the same species as *Pleuronectes asperrimus* of Japan.

Smitt suggests in one passage that the forms which culminate in the plaice and flounder started from one of the three *limanda* (dab) *glacialis* or *cicatricosus*, and considers the latter two varieties to be diverging in the same directions as *flesus* and *platessa.* Duncker, on the other hand, considers the plaice the oldest form on account of its cycloid scales, and to have come from the far north; to have formed the variety *glacialis* on the Arctic coasts, and then with this variety to have entered the Baltic, where the plaice gave rise to the Baltic form of plaice, and the *glacialis* to the flounder.

The conclusions at present suggested by the facts to my own mind are as follows: The plaice is by no means necessarily the original form, as there is reason for holding that the original form of these and other flat-fishes had ctenoid scales of the usual kind, as in the dab. The facts show that the species *glacialis* is the Arctic form, the flounder the fluviatile form of the plaice. Whatever the causes which led to the reduction of the scales in the plaice, it is certain that the ctenoid condition is more developed in the Arctic form: this form is also without tubercles and has fewer fin-rays. There are objections to the view, which Duncker appears to take, that the development of the tubercles in the flounder is a further stage in the development of the spinules on the scales in the plaice and in *glacialis.* The most spinulated scales occur in the two latter forms on the fin-rays and in the interspinous regions, while in the flounder it is precisely in these two regions that the scales are most rudimentary, and along the base of the fins and along the lateral line the scales are developed into spiny tubercles. As we have seen, the spinules on the fin-rays are retained to some extent only in the smoothest flounders, those of the Mediterranean, while in those of more northern latitudes the fin-rays are scaleless. Thus we might almost say that the condition of the flounder was due to the further progress of a modification in the same direction as that of the plaice, that the ctenoid scales first underwent reduction, and then when they had become rudimentary some of them in particular parts of the body developed into tubercles. This view, however, is not consistent with the fact that both plaice and flounder become rougher, their calcified skin armature more developed, in the north than in the south. The correct interpretation of this fact is evidently that the development of scales has taken a different direction in the flounder, and that in both directions cold, or some condition accompanying a northern climate, has the effect of producing enlargement of the structures connected with the scales. It is not possible at present to see any connection between the fact that the flounder lives in rivers, and the peculiar development of its tubercles, nor can we see any advantage to the fish in the possession of these structures.

We do not find that the correspondence which is observed between climate and development of spines on the scales in the plaice and flounder exists when we compare the species of flat-fishes with one another. The sole, for instance, is a distinctly southern form, and its scales are strongly ctenoid all over the body. The dab, however, is more closely allied to the plaice and flounder, and also has ctenoid scales all over its body, except the area covered by the pectoral fin; ctenoid scales extend also on to the fin-rays. Now it is not a fact that the dab inhabits more northern regions than the plaice, and still less than *glacialis*. On the contrary the dab and plaice are constantly taken together on the same ground. The dab extends on the European coast from the Bay of Biscay to the Kara Sea, and is plentiful on the south coast of Iceland, and is found in the Baltic at least as far east as Gothland. On the American side of the Atlantic the dab lives in the same latitudes as *glacialis*, but in a slightly different form, described by American naturalists as a distinct species, under the name *Limanda ferruginea*. In the North Pacific, however, we do find that the local form of the dab, like the local form of the flounder, is rougher than in other parts of the world. This form is described under the name *Limanda aspera*, and extends from Sitka and Saghalien to Wrangel Island off the coast of Siberia. Thus, although we find here again that rougher scales in the same species characterise the more northern forms, and appear to indicate a direct influence of climate, we do not find that northern and southern species are constantly distinguished by a similar difference in the character of the scales. The occurrence of spinulation as a secondary sexual character, developing in the males, as such characters generally do, only when maturity is reached, is peculiar to the plaice, and at present we have no evidence that, as Duncker suggests, the character is of any importance in the relations of the sexes.

A.—TABLES SHOWING THE CHARACTERS OBSERVED IN EACH SPECIMEN EXAMINED.

The specimens of each sex in each locality are arranged in order of size.

The Height of Body, Length of Head, Length of Caudal Peduncle, and Length of Caudal Fin, are expressed in hundredths of the Total Length. The Total Length is measured from the extremity of the lower jaw to the end of the middle ray of the caudal fin.

The degrees of spinulation of the scales, often called ciliation, are as follows:—

1. On the fin-rays only: the numbers of spinulated dorsal rays and ventral rays are added together in one column; the degree on the body is shown in the next column.
2. On the fin-rays, and also on the head in front of the preopercular bone.
3. Also on the operculum.
4. Also on the body in the region of the interspinous bones.
5. Also on a greater extent of the body.

Locality: Plymouth—grounds near Eddystone.

MALES. TOTAL NUMBER, 15.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill-Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
29·3	40	23	5	20	5	9	71	54	Commencing	0	i
29·4	39	23	5	19	5	11	74	55	0	0	m
30·2	38	22	6	19	5	10	73	56	36	2	m
32·2	36	22	5	18	3	9	76	56	37	2	i
32·3	37	21	5	19	4	11	72	53	37	2	m
32·4	39	21	6	18	5	10	74	55	31	0	i
32·5	38	23	6	20	6	11	70	52	58	4	m
32·8	40	21	6	19	5	10	67	53	40	0	?
33·3	39	23	6	19	6	10	72	52	0	0	?
33·5	37	22	5	19	5	9	71	53	55	3	m
33·7	38	21	5	17	5	10	77	58	40	2	m
33.9	41	22	6	18	5	9	72	51	50	2	?
37·4	39	22	5	18	5	10	73	53	43	2	m
38·7	37	21	5	19	4	10	75	56	37	0	m
42·4	35	21	5	18	3	11	69	52	40	0	m

FEMALES. TOTAL NUMBER, 21.

29·5	38	23	6	18	5	9	75	56	—	—	i
30·1	38	22	5	19	5	10	75	57	—	—	i
30·2	40	21	5	19	5	10	75	55	—	—	i
30·7	37	23	6	18	5	10	74	55	—	—	m
30·7	41	24	5	19	5	10	72	55	—	—	i
31·1	38	22	6	20	5	9	76	56	—	—	i
31·7	39	22	5	18	5	10	75	53	—	—	m
32·1	39	21	6	19	5	?	75	55	—	—	i
32·2	38	22	5	19	5	10	74	56	—	—	m
32·5	38	22	6	20	5	10	74	55	—	—	i
34·6	38	22	5	17	5	9	75	56	—	—	i
35·2	38	23	6	23	5	10	66	53	—	—	m
35·5	40	21	7	17	7	10	71	51	—	—	i
36·1	41	22	6	18	6	10	74	54	—	—	m
37·4	40	23	5	18	5	10	72	52	—	—	m
38·6	38	22	6	18	4	10	74	56	—	—	m
39·0	38	22	5	18	5	10	72	55	—	—	m
39·0	37	23	5	20	5	11	75	56	—	—	m
40·5	36	21	6	18	5	11	72	56	—	—	m
42·6	38	21	5	17	5	10	76	57	—	—	m
43·3	39	23	6	18	5	9	68	51	—	—	m

Locality: Brown Ridges, North Sea.

MALES. TOTAL NUMBER, 52.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
22·1	36	24	5	18	5	11	72	53	0	0	i
24.9	37	22	5	21	5	10	68	51	0	0	i
26·2	39	21	6	18	5	11	74	55	42	0	?
26·9	40	22	6	18	5	9	73	55	29	0	i ?
27·5	39	22	6	17	5	10	73	54	17	0	i ?
27·5	38	22	6	18	5	9	74	56	9	0	i ?
27·7	37	21	6	18	5	9	71	53	35	0	?
28·1	·39	22	6	18	5	10	72	53	36	2	—
28·3	39	22	6	18	5	10	78	57	37	0	—
28·4	39	22	6	19	5	9	76	55	34	2	m
28·5	38	23	5	19	5	10	78	55	26	0	—
28·6	39	22	5	17	5	10	73	56	42	2	m
28·8	37	22	5	19	5	9	73	53	32	0	—
28·8	38	21	6	18	5	10	69	53	42	0	—
29·2	40	22	5	17	6	9	73	52	36	2	—
29·3	37	22	5	18	5	10	75	54	39	0	—
29·5	38	22	6	18	5	10	73	52	39	2	m
29·6	39	22	6	18	5	10	71	51	21	0	—
30 0	38	22	6	18	5	11	71	52	24	0	—
30·0	40	23	6	19	5	10	72	53	10	0	—
30·1	37	22	6	18	5	10	76	56	42	2	m
30·1	39	21	6	17	5	12	72	55	32	0	—
30·3	37	22	5	18	5	10	74	55	40	2	—
30·3	40	22	6	18	6	11	75	55	25	2	m
30·7	40	22	5	17	5	10	74	55	37	0	—
30·7	38	23	5	22	5	10	70	51	9	0	—
31·2	38	22	7	17	5	10	73	55	47	3	m
31·6	41	22	6	18	5	9	77	58	33	0	m
31·8	38	22	5	18	5	10	70	55	48	2	—
32·0	38	21	6	21	6	9	73	54	37	2	m
32·1	38	23	6	19	5	9	72	53	41	2	m
32·3	39	22	6	16	5	9	73	55	47	2	—
32·4	38	21	6	18	6	9	70	52	41	2	m
32·9	36	21	6	18	6	9	70	53	34	0	—
32·9	39	22	5	20	5	10	69	50	35	2	—
33·2	37	21	6	18	5	10	73	53	36	2	—
33·4	39	22	6	18	5	10	68	50	26	2	m
33·8	36	20	4	17	5	11	71	55	39	3	—
33·8	36	21	4	17	5	9	75	58	47	2	—
34·1	36	20	6	16	6	10	76	53	25	2	—
34·2	36	22	5	19	5	10	75	57	0	0	—
34·2	39	22	5	19	5	11	73	52	37	0	m
34·6	40	21	7	19	5	9	75	55	17	0	m
34·8	37	22	6	18	5	11	68	51	26	0	—

MALES—*continued.*

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
34·8	40	20	5	18	5	9	67	51	39	2	—
35·1	36	20	6	17	5	9	76	56	35	3	—
35·4	35	20	6	19	5	11	74	56	44	2	—
35·7	38	22	6	17	6	11	76	56	2	0	—
35·8	39	20	7	18	7	10	71	52	41	2	—
35·8	39	20	5	18	5	11	69	54	36	3	m
36·0	40	21	6	17	7	10	74	55	39	2	—
36·8	41	22	5	18	6	10	75	58	41	2	m

FEMALES. TOTAL NUMBER, 57.

24·9	37	22	6	18	5	12	72	51	0	0	m
25·1	37	22	5	18	6	10	77	57	—	—	i?
25·1	40	24	6	19	6	10	72	50	—	—	i
26·0	38	23	6	19	5	10	71	51	—	—	i
26·1	39	23	5	18	5	10	70	52	—	—	—
26·4	36	23	6	18	5	9	70	51	—	—	i
26·6	39	23	7	17	5	10	72	55	—	—	i
26·7	38	22	5	18	5	10	71	54	—	—	i
27·0	37	22	5	19	5	9	72	55	—	—	i
27·5	39	23	5	19	5	10	73	54	—	—	i
27·7	39	22	6	17	5	—	74	56	—	—	—
27·8	39	23	6	20	5	9	72	55	—	—	i
28·1	40	22	6	17	5	10	75	57	—	—	i
28·2	38	23	6	17	5	10	76	57	—	—	i
28·5	37	23	6	17	5	11	70	50	—	—	i
28·8	39	22	5	17	5	11	70	54	—	—	m
29·7	38	23	7	17	5	9	69	51	—	—	i
29·8	38	23	6	18	5	10	76	58	—	—	i
29·8	38	22	6	18	5	10	75	54	—	—	i
30·3	39	22	6	18	5	10	76	56	—	—	i
30·4	38	22	6	18	5	10	79	58	—	—	i
30.5	40	23	6	18	6	11	77	55	—	—	i
30·5	37	21	6	18	6	10	70	52	—	—	i
30·6	39	22	5	19	6	11	76	58	—	—	i
30·6	38	22	7	17	5	10	75	53	19	0	m
30·8	41	21	6	20	5	10	75	55	—	—	m
31·1	38	22	6	18	5	10	71	52	—	—	m
31·2	37	23	6	20	5	11	69	51	—	—	—
31·2	40	21	6	17	5	10	78	57	—	—	i
31·2	38	22	5	19	5	10	71	52	—	—	m
31·6	40	22	5	18	5	10	73	53	—	—	m
31·6	40	22	5	19	5	10	71	51	—	—	—
31·7	39	22	6	18	5	10	81	59	—	—	i
31·9	36	21	6	17	5	9	75	58	—	—	i
31·9	39	23	5	18	6	9	73	55	—	—	—

Locality: Brown Ridges, North Sea.

FEMALES—*continued.*

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles	Gill Rakers.	D. Rays.	A Rays.	Ciliated Rays.	Cil. Body.	Maturity.
31·9	41	22	5	17	5	10	74	55	—	—	i
32·1	38	23	5	18	5	10	70	52	—	—	i
32·4	39	23	6	17	6	11	74	52	—	—	m
32·6	37	23	6	18	5	11	76	55	—	—	—
33·3	36	23	6	17	5	10	79	57	—	—	—
33·4	39	23	6	18	6	10	69	50	—	—	—
33·9	36	21	5	18	5	10	75	55	—	—	—
34·0	40	22	5	18	5	10	70	51	—	—	—
34·2	39	22	6	18	5	9	79	57	—	—	—
34·3	39	21	6	18	6	10	68	53	—	—	—
34·3	39	22	5	17	5	11	74	54	—	—	m
34·8	36	20	5	17	5	10	74	55	—	—	—
34·8	40	22	6	18	5	10	73	54	—	—	m
36·1	36	21	6	18	6	9	73	56	—	—	—
36·2	39	22	6	18	5	11	77	57	—	—	—
36·4	39	23	6	19	6	10	68	52	—	—	m
37·0	38	22	6	17	6	11	77	55	—	—	m
37·3	39	21	5	19	5	10	71	55	—	—	m
37·7	39	22	6	18	5	10	68	54	—	—	m
38·4	41	23	5	19	5	13	64	48	—	—	m
38·9	39	23	5	18	5	10	76	56	—	—	m
39·4	39	22	5	18	5	11	76	55	—	—	m

Locality: Norfolk Coast.

MALES. TOTAL NUMBER 49.

Length cm.	Ht. of Body	Length of Head	Cau. Ped.	Cau. Fin	Tubercles	Gill Rakers	D. Rays	A. Rays	[illegible] Rays	Th. Body	Maturity
20·7	45	23	6	19	5	10	75	54	7	6	—
20·5	40	24	6	17	5	10	73	55	21	6	—
23·5	37	24	6	20	4	9	69	53	4	6	—
24·6	38	23	6	19	6	11	73	53	21	6	—
24·5	38	23	6	16	5	10	67	51	35	6	—
25·2	41	22	6	17	5	11	74	54	17	6	—
25·5	38	23	6	18	5	11	72	56	27	6	—
25·5	41	22	6	20	5	9	71	54	1 fin missing	—	—
26·1	37	23	6	19	5	11	76	54	25	6	1
26·5	40	22	6	19	4	8	72	52	4	6	—
27·1	37	22	6	18	5	10	72	55	16	6	1
27·3	38	22	6	18	5	10	67	49	35	7	—
28·5	38	22	6	19	4	12	75	57	17	6	—
28·6	38	23	5	18	7	11	71	55	43	6	—
29·2	40	21	6	19	5	11	74	57	37	6	—
29·5	39	22	7	18	5	10	72	52	37	6	—
29·5	42	22	7	17	5	9	70	54	35	6	—
29·7	41	23	6	21	6	11	69	53	35	6	—
30·1	38	22	6	19	5	10	73	52	33	6	—
30·9	38	23	6	18	5	9	74	53	4	6	—
30·6	41	24	6	17	5	11	69	51	11	6	—
31·5	37	21	6	19	5	9	74	59	57	6	—
32·6	38	22	5	20	5	10	71	53	44	6	—
33·1	39	22	6	20	5	9	71	55	42	6	—
33·2	37	21	6	18	5	10	71	55	34	6	—
33·2	39	23	6	19	6	9	74	54	6	6	—
33·9	41	23	6	16	5	11	75	60	23	6	1
34·1	35	22	5	18	5	10	70	57	29	6	1
34·1	37	22	5	18	6	10	73	54	16	6	—
35·3	41	21	5	17	4	10	76	57	20	6	—
35·5	38	21	5	20	4	10	72	57	45	6	—
35·5	39	23	6	18	6	10	72	55	25	6	—
35·5	38	23	6	19	5	10	72	57	1 fin missing	6	1
35·7	38	22	6	17	5	10	73	57	49	6	—
36·3	36	21	6	17	6	10	74	53	26	6	—
36·5	39	23	6	18	6	9	70	56	6	6	—
36·5	38	22	6	18	5	10	76	53	41	6	—
36·9	39	22	6	20	4	9	74	55	37	6	—
37·6	37	21	6	19	5	10	72	57	26	6	—
37·7	39	21	6	20	4	10	71	54	32	6	—
38·0	38	21	6	18	5	—	70	56	20	6	—
38·6	40	21	5	19	5	10	71	51	4	6	—
39·5	38	22	5	19	5	10	74	54	38	6	—
41·5	40	21	6	18	4	10	71	54	33	6	—
42·5	38	23	6	19	5	11	72	51	25	6	—
42·6	40	22	5	19	5	10	74	56	56	6	—
43·1	41	21	6	19	5	10	74	59	42	6	—
43·9	40	22	6	19	6	11	74	58	38	6	—
45·6	38	22	6	17	4	10	74	57	44	6	—

Locality: Norfolk Coast.

FEMALES. TOTAL NUMBER, 91.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
21·5	37	22	6	19	5	9	70	54	—	—	i
22·7	39	23	7	19	5	9	71	55	—	—	i
22·7	40	24	5	19	5	10	73	53	—	—	i
23·0	40	23	6	18	5	10	73	56	—	—	i
23·9	39	23	6	19	5	10	71	56	—	—	i
24·7	39	23	6	18	5	9	76	56	—	—	i
25·6	37	22	7	17	5	9	76	56	—	—	i
27·0	39	22	5	18	5	10	78	57	25	—	i
27·4	40	24	5	19	6	10	69	52	—	—	i
27·5	39	22	6	18	5	10	74	57	—	—	i
28·5	41	23	5	20	7	10	75	54	—	—	i
28·7	38	22	7	18	5	10	74	56	—	—	i
28·8	39	24	5	19	5	13	74	54	—	—	i
28·9	40	22	6	19	5	10	72	54	—	—	i
29·4	37	22	6	19	5	11	71	53	—	—	i
30·5	40	23	6	19	4	11	75	55	—	—	i
31·4	39	23	6	18	5	10	72	54	—	—	i
31·6	38	23	6	17	5	11	72	54	—	—	i
31·9	37	22	6	18	5	9	72	53	—	—	i
32·0	39	22	6	20	5	9	72	54	—	—	i
32 2	42	22	6	19	5	10	73	54	—	—	i
33·2	42	23	5	19	5	11	73	52	—	—	i
33·6	37	22	6	19	6	12	73	52	—	—	i
33·8	41	23	5	20	5	10	71	51	—	—	i
33·8	39	22	7	19	5	10	74	55	—	—	i
33·9	38	21	6	19	5	11	71	53	—	—	i
34·2	38	23	5	19	5	10	73	53	—	—	i
34·7	39	21	5	20	5	11	75	55	—	—	i
34·9	40	21	6	19	5	10	74	55	—	—	i
34·9	41	23	6	19	5	10	72	52	—	—	i
35·1	39	22	6	19	5	11	72	52	—	—	i
35·1	38	24	6	17	5	9	73	53	—	—	i
35·1	37	23	6	18	6	8	71	53	—	—	i
35·4	38	22	5	19	6	11	72	54	—	—	m
35·5	40	23	6	19	5	11	74	53	—	—	i
35·7	39	22	6	18	5	9	70	53	—	—	i
36·0	40	23	6	20	5	10	72	52	—	—	i
36·5	38	22	6	19	7	9	76	54	—	—	i
36·6	39	22	6	18	5	9	72	54	—	—	i
36·6	37	22	5	18	5	10	79	61	—	—	i
36·7	42	23	5	18	5	8	67	52	—	—	i
36·7	39	23	5	19	5	10	70	52	—	—	—
37·0	37	24	6	18	5	11	78	57	—	—	i
37·9	37	23	6	18	5	11	70	52	—	—	i
37·9	36	23	6	19	3	10	78	57	—	—	m
38·2	37	23	6	18	5	11	72	55	—	—	m
38·5	39	22	5	19	5	12	72	53	—	—	m
38·6	40	22	5	20	4	11	73	53	—	—	m
38·8	38	22	6	18	4	—	70	51	20	0	i

FEMALES—*continued.*

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
39·1	39	23	6	17	5	9	72	53	—	—	m
39·2	42	22	6	18	5	9	76	54	—	—	i
39·8	38	24	5	19	5	9	73	54	—	—	m
40·0	40	22	6	19	5	10	75	56	—	—	i
40·2	40	22	5	19	5	11	74	53	—	—	m
40·3	38	23	6	18	5	11	68	50	—	—	i
40·5	39	22	6	19	5	11	70	51	—	—	—
40·7	39	22	6	19	5	10	69	52	—	—	m
40·7	37	22	5	17	5	10	76	56	—	—	m
40·9	39	22	7	18	5	10	75	56	—	—	—
41·8	38	22	5	19	5	11	76	55	—	—	m
42·5	39	23	5	20	5	10	74	55	—	—	i
43·4	43	22	5	18	5	10	71	55	—	—	m
43·7	37	22	5	19	5	12	75	58	—	—	m
44·0	42	23	5	20	4	10	74	55	—	—	m
44·7	39	21	6	20	5	10	73	55	—	—	m
45·0	39	22	6	20	5	10	73	55	—	—	m
45·0	38	22	6	16	5	10	71	54	—	—	m
45·5	37	23	6	17	5	12	75	55	—	—	m
45·7	37	22	5	18	5	10	75	55	23	—	m
46·0	36	22	6	18	4	10	76	57	—	—	m
46·2	40	21	6	19	5	9	73	53	—	—	m
46·3	39	23	6	18	6	10	71	52	—	—	m
46·8	39	23	5	18	3	11	70	52	—	—	m
47·4	40	22	7	17	5	10	70	53	—	—	m
47·5	38	23	5	17	4	11	78	56	—	—	m
48·2	40	23	6	18	5	9	74	55	—	—	m
49·2	37	23	6	18	5	10	74	56	—	—	m
49·3	39	23	5	18	4	12	76	56	—	—	m
49·5	40	25	5	18	4	10	70	54	—	—	m
49·7	38	23	5	19	5	11	73	53	—	—	m
51·0	39	21	6	17	5	11	76	57	—	--	m
51·6	37	23	6	18	5	10	71	57	—	—	m
51·9	38	23	5	17	2	10	74	55	—	—	m
52·7	36	23	5	18	2	9	73	54	—	—	m
52·8	38	22	6	19	5	10	75	53	—	—	m
52·9	38	21	5	19	3	8	72	54	—	—	m
54·8	38	22	5	20	3	11	75	55	—	—	m
55·9	39	23	5	20	5	11	76	57	—	—	m
56·3	38	25	5	17	5	8	75	55	—	—	m
56·8	40	24	5	16	5	11	72	52	—	—	m
63·0	36	24	5	16	5	11	76	56	--	—	m

Locality: North-eastern end of Dogger Bank, 25 fathoms.

MALES. TOTAL NUMBER, 16.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
28·7	38	22	5	19	5	13	72	54	0	0	i
32·8	40	22	7	18	5	10	70	53	0	0	i
32·9	41	21	6	19	5	10	73	54	33	2	i
35·3	40	20	7	18	5	11	70	52	44	3	m
35·4	39	23	6	18	5	10	69	54	17	2	i
36·2	38	22	6	17	5	10	70	55	36	2	?
38·9	40	22	5	19	5	11	74	56	34	2	m
39·2	41	22	6	18	6	9	70	53	34	0	—
42·1	42	21	5	19	6	12	73	54	42	2	m
42·6	41	21	6	19	5	10	68	52	31	4	m
42·7	42	22	6	17	5	10	69	52	44	4	m
43·4	42	22	7	16	5	10	72	55	39	4	m
43·4	40	23	6	18	5	9	74	54	42	4	m
46·2	42	21	6	18	5	10	74	52	41	4	m
47·1	39	21	5	19	7	10	70	55	43	4	m
47·3	35	19	5	17	5	9	75	54	48	5	m
FEMALES. TOTAL NUMBER, 27.											
30·6	41	23	6	18	5	10	75	53	—	—	i
31·3	38	24	6	19	5	10	72	54	—	—	i
33·4	38	23	5	18	5	11	71	54	—	—	i
35·0	39	22	6	19	6	9	74	53	—	—	i
35·2	40	22	6	17	5	10	73	55	—	—	i
38·5	41	22	6	18	6	11	75	55	—	—	i
40·0	43	23	7	18	5	11	74	54	—	—	?
40·1	37	22	6	19	5	10	75	57	—	—	i
40·4	42	23	5	19	5	10	72	53	—	—	i
40·7	41	23	6	18	5	11	72	53	—	—	m
42·8	40	22	6	18	6	11	70	53	—	—	m
43·5	41	21	6	17	4	11	76	56	—	—	i
44·1	39	23	6	19	5	11	72	54	—	—	i
44·4	39	22	6	17	6	10	76	57	—	—	m
44·7	40	23	6	19	7	12	72	53	—	—	i
45·0	42	22	6	19	5	10	75	54	—	—	m
45·1	40	21	6	18	6	11	70	55	—	—	m
45·1	39	22	6	17	5	10	72	55	—	—	m
45·6	38	21	5	17	5	10	80	56	—	—	m
45·7	39	22	5	17	6	12	77	56	—	—	m
45·9	39	22	6	18	5	9	74	56	—	—	m
49·2	41	22	6	16	5	10	79	58	—	—	m
49·3	41	21	6	17	5	11	77	60	—	—	m
50·4	39	21	6	18	6	10	76	57	—	—	m
53·2	40	21	5	17	6	11	74	55	2	2 (trace)	m
55·9	40	22	6	18	5	11	72	54	0	2 (trace)	m
57·0	41	24	6	17	5	10	69	52	—	—	m

Locality: Off South Coast of Iceland.

Specimen in spirit, collected by Mr. Holt.

MALE.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
60·6	40	21	6	19	5	9	72	54	47	5	—

Locality: Fisher Bank, North Sea.

Specimen in spirit, collected by Mr. Holt.

MALE.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
49·1	37	23	6	17	5	11	74	55	51	5	—

Locality: Baltic Sea.

Specimens in spirit, sent to Mr. Holt from Hamburg, probably caught near Kiel.

MALES.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
23·5	36	23	6	20	4 (flat)	9	64	47	50	4	—
23·8	40	23	7	19	5	9	70	54	50	5	—
24·1	37	23	6	21	5	10	69	52	55	5	—
24·2	38	23	5	21	5 (flat)	9	69	52	49	5	—
25·3	38	22	7	21	5	11	65	48	29	5	—
29·4	38	23	7	19	4	10	73	53	44	5	—

FEMALES.

23·4	38	25	6	21	5	10	63	48	—	—	m
25·2	39	25	6	22	6	9	70	51	—	—	m
26·8	39	23	6	20	6	11	67	54	—	—	m
30·4	37	22	6	20	6	9	70	55	—	—	m
31·5	41	23	6	17	5	9	75	54	—	—	m

SPECIMENS IN THE BRITISH MUSEUM COLLECTION.

Variety of *Pleuronectes platessa*.

Collected by U.S. Fishery steamer *Albatross*, at Herendeen Bay, Alaska.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
23·3	42	24	6	18	5	—	70	51	40	0	♂ i

Varieties of *Pleuronectes glacialis*.

Collected by U.S. Fishery steamer in Nushagak River, Alaska.

18·3	39	23	9	16	0	—	55	41	many	5	♀ i
17·1	?	24	8	16	0	—	59	40	many	4	♀ i

Collected at Kotzebue Sound, Alaska.

18·3	39	23	9	16	0	—	53	39	34	5	♀ m

Varieties of *Pleuronectes flesus*.

Pl. Italicus, Günther; *passer*, Bonaparte.

Specimens from Dalmatia.

13·7	37	22	7	18	2	—	58	42	0	—	i
19·6	36	23	8	18	2	—	62	42	22	—	♀ i
20·1	37	23	8	18	2	—	59	42	1	—	?

Pl. luscus, Pallas.

Specimens from the Bosphorus.

28·3	42	22	7	18	2	—	60	43	few	—	♀ m
28·3	37	22	8	18	2	—	56	41	28	—	♂ m

Specimens from the Black Sea.

10·5	41	23	6	18	2	—	59	42	some	—	—
10·7	38	25	8	18	2	—	57	43	some	—	—
14·2	39	25	6	21	2	—	60	41	some	—	—

Specimens from Constantinople, labelled *Platessa vulgaris*.

29·1	41	23	8	19	2	—	57	42	some	—	—
34·6	43	21	8	16	2	—	59	43	some	—	—

B.—TABLES SHOWING THE NUMBER OF INDIVIDUALS IN WHICH EACH OBSERVED VARIATION OCCURRED.

Height of Body in hundredths of Total Length.	Plymouth.		Brown Ridges.		Norfolk Coast.		N.E. of Dogger Bank.		Southern.		Northern.	
	(15)	(21)	(52)	(57)	(49)	(91)	(16)	(27)	(67)	(78)	(65)	(118)
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
35	1	—	1	—	—	—	1	—	2	—	1	—
36	1	1	7	6	4	4	0	—	8	7	4	4
37	3	2	8	7	6	16	0	1	11	9	6	17
38	3	10	12	12	13	19	2	3	15	22	15	22
39	4	3	14	21	10	27	2	7	18	24	12	34
40	2	3	8	8	11	16	4	6	10	11	15	22
41	1	2	2	3	2	3	3	7	3	5	5	10
42	—	—	—	—	2	5	4	2	—	—	6	7
43	—	—	—	—	0	1	—	1	—	—	0	2
44	—	—	—	—	0	—	—	—	—	—	0	—
45	—	—	—	—	1	—	—	—	—	—	1	—
Length of Head, ditto.												
19	—	—	—	—	—	—	1	—	—	—	1	—
20	—	—	7	1	—	—	1	—	7	1	1	—
21	6	5	11	8	12	7	5	6	17	13	17	13
22	5	9	29	26	26	38	7	12	34	35	33	50
23	4	6	4	21	8	36	2	7	8	27	10	43
24	—	1	1	1	3	8	—	2	1	2	3	10
25	—	—	—	—	—	2	—	—	—	—	—	2
Caudal Peduncle, ditto.												
4	—	—	2	—	—	—	—	—	2	—	—	—
5	9	10	17	21	12	37	5	5	26	31	17	42
6	6	10	30	33	35	48	8	21	36	43	43	69
7	—	1	3	3	2	6	3	1	3	4	5	7

	Length of Caudal Fin, ditto.	Plymouth.		Brown Ridges.		Norfolk Coast.		N.E. of Dogger Bank.		Southern.		Northern.	
		♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
	16	—	—	2	—	—	3	1	1	2	—	1	4
	17	1	3	11	16	7	11	3	9	12	19	10	20
	18	5	9	26	28	14	30	6	10	31	37	20	40
	19	7	5	9	10	20	35	6	7	16	15	26	42
	20	2	3	1	3	7	12	—	—	3	6	7	12
	21	—	0	2	—	1	—	—	—	2	0	1	—
	22	—	0	1	—	—	—	—	—	1	0	—	—
	23	—	1	—	—	—	—	—	—	—	1	—	—
	Number of Tubercles.												
	2	—	—	—	—	—	2	—	—	—	—	—	2
	3	2	—	—	—	1	4	—	—	2	—	1	4
	4	2	1	—	—	7	8	—	1	2	1	7	9
	5	9	18	42	45	33	70	13	17	51	63	46	87
	6	2	1	8	12	7	5	2	8	10	13	9	13
	7	—	1	2	—	1	2	1	1	2	1	2	3
	Gill Rakers.		*		*	*	*						
	8	—	—	—	—	1	4	—	—	—	—	1	4
	9	4	4	16	8	9	16	3	2	20	12	12	18
	10	7	14	25	35	30	39	9	12	32	49	39	51
	11	4	2	10	11	6	25	2	11	14	13	8	36
	12	—	—	1	1	2	5	1	2	1	1	3	7
	13	—	—	—	1	—	1	1	—	—	1	1	1

* Not noted in one specimen of each of these groups.

	Dorsal Rays.												
ζ	64	—	—	—	1	—	—	—	—	—	1	—	—
	65	—	—	—	0	—	—	—	—	—	0	—	—
η	66	—	1	—	0	—	—	—	—	—	1	—	—
	67	1	0	1	0	2	1	—	—	2	0	2	1
	68	0	1	3	3	0	1	1	—	3	4	1	1
	69	1	0	3	3	3	2	2	1	4	3	5	3
	70	1	0	4	7	4	9	5	2	5	7	9	11
θ	71	2	1	5	6	6	10	0	1	7	7	6	11
	72	3	4	5	5	5	15	2	7	8	9	7	22
	73	2	0	11	5	8	14	2	1	13	5	10	15
	74	2	5	6	5	10	12	3	4	8	10	13	16
	75	1	7	6	6	3	11	1	4	7	13	4	15
ι	76	1	2	5	7	6	11	—	3	6	9	6	14
	77	1	—	1	4	0	0	—	2	2	4	0	2
	78	—	—	2	1	1	4	—	0	2	1	1	4
	79	—	—	—	3	1	1	—	1	—	3	1	2
	80	—	—	—	0	—	—	—	1	—	0	—	1
	81	—	—	—	1	—	—	—	—	—	1	—	—

Anal Rays.		Plymouth.		Brown Ridges.		Norfolk Coast.		N.E. of Dogger Bank.		Southern.		Northern.	
		♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
γ	48	—	—	—	1	—	—	—	—	—	1	—	—
	49	—	—	—	0	1	—	—	—	—	0	1	—
	50	—	—	2	3	0	1	—	—	2	3	0	1
δ	51	—	2	5	7	4	3	—	—	5	9	4	3
	52	3	1	6	7	3	13	4	1	9	8	7	14
	53	4	2	10	3	10	17	2	6	14	5	12	23
	54	2	1	4	7	10	17	6	6	6	8	16	23
	55	2	6	14	13	4	18	3	5	16	19	7	23
ε	56	3	7	6	4	8	12	1	4	9	11	9	16
	57	0	2	2	7	7	8	—	3	2	9	7	11
	58	1	—	3	4	1	1	—	1	4	4	1	2
	59	—	—	—	1	1	0	—	0	—	1	1	0
	60	—	—	—	—	—	0	—	1	—	—	—	1
	61	—	—	—	—	—	1	—	—	—	—	—	1

Ciliation.	Plymouth.		Brown Ridges.		Norfolk Coast.		N.E. of Dogger Bank.		Southern.		Northern.	
	♂	♀	♂*	♀	♂*	♁	♂	♀	♂		♂	
None	2	—	1	56	3	88	2	25	3	—	5	—
1. Fins only	5	—	22	1	15	3	1	0	27	—	16	—
2. Also head	6	—	23	—	18	—	5	2	29	—	23	—
3. Also operculum..	1	—	4	—	3	—	1	—	5	—	4	—
4. Also interspinous region	1	—	—	—	2	—	6	—	1	—	8	—
5. More	—	—	—	—	—	—	1	—	—	—	1	—

* Specimens under 26 cm. in length not included.

TABLE SHOWING THE FREQUENCY OF EACH VARIATION WITHOUT SEPARATION OF SEXES.

Height of Body.	Plymouth.	Brown Ridges.	Norfolk Coast.	N.E. of Dogger Bank.	Southern.	Northern.
	(36)	(109)	(140)	(43)	(145)	(183)
35	1	1	—	1	2	1
36	2	13	8	0	15	8
37	5	15	22	1	20	23
38	13	24	32	5	37	37
39	7	35	37	9	42	46
40	5	16	27	10	21	37
41	3	5	5	10	8	15
42	—	—	7	6	—	13
43	—	—	1	1	—	2
44	—	—	0	—	—	0
45	—	—	1	—	—	1
Length of Head.						
19	—	—	—	1	—	1
20	—	8	—	1	8	1
21	11	19	19	11	30	30
22	14	55	64	19	69	83
23	10	25	44	9	35	53
24	1	2	11	2	3	13
25	—	—	2	—	—	2
Caudal Peduncle.						
4	—	2	—	—	2	—
5	19	38	49	10	57	59
6	16	63	83	29	79	112
7	1	6	8	4	7	12
Caudal Fin.						
16	—	2	3	2	2	5
17	4	27	18	12	31	30
18	14	54	44	16	68	60
19	12	19	55	13	31	68
20	5	4	19	—	9	19
21	0	2	1	—	2	1
22	0	1	—	—	1	—
23	1	—	—	—	1	—
Number of Tubercles.						
2	—	—	2	—	—	2
3	2	—	5	—	2	5
4	3	—	15	1	3	16
5	27	87	103	30	114	133
6	3	20	12	10	23	22
7	1	2	3	2	3	5

Gill Rakers.	Plymouth.	Brown Ridges.	Norfolk Coast.	N.E. of Dogger Bank.	Southern.	Northern.
8	—	—	5	—	—	5
9	8	24	25	5	32	30
10	21	60	69	21	81	90
11	6	21	31	13	27	44
12	—	2	7	3	2	10
13	—	1	1	1	1	2
Dorsal Rays.						
64	—	1	—	—	1	—
65	—	0	—	—	0	—
66	1	0	—	—	1	—
67	1	1	3	—	2	3
68	1	6	1	1	7	2
69	1	6	5	3	7	8
70	1	11	13	7	12	20
71	3	11	16	1	14	17
72	7	10	20	9	17	29
73	2	16	22	3	18	25
74	7	11	22	7	18	29
75	8	12	14	5	20	19
76	3	12	17	3	15	20
77	1	5	0	2	6	2
78	—	3	5	0	3	5
79	—	3	2	1	3	3
80	—	0	—	1	0	1
81	—	1	—	—	1	—
Anal Rays.						
48	—	1	—	—	1	—
49	—	0	1	—	0	1
50	—	5	1	—	5	1
51	2	12	7	—	14	7
52	4	13	16	5	17	21
53	6	13	27	8	19	35
54	3	11	27	12	14	39
55	8	27	22	8	35	30
56	10	10	20	5	20	25
57	2	9	15	3	11	18
58	1	7	2	1	8	3
59	—	1	1	0	1	1
60	—	—	0	1	—	1
61	—	—	1	—	—	1

The Oyster Culture of the Ancient Romans.

By

R. T. Günther, M.A.,

Fellow of Magdalen College, Oxford.

With Plate I.

WHILE engaged in the examination of some vase pictures which have been stated to represent certain parts of the shores of the Bay of Pozzuoli as it existed in Roman times, I was struck by two drawings of Roman oyster culture grounds, or ostrearia, which seem to me to be of considerable interest, not only as affording us direct information concerning the method of oyster culture employed by the Romans in the neighbourhood of Baiæ, but also because they show clearly that that method was the same as the one which still survives and is still carried on, in common with so many other Roman customs in the same locality, exactly as it was nearly two thousand years ago.

Our knowledge of the methods pursued by the Romans in the cultivation of oysters is derived from two sources. In the first place we meet with scattered allusions to oysters and their cultivation in many classical authors; and secondly, there are still preserved to us certain vases decorated with views of the apparatus employed in oyster culture.

Although passages alluding to oysters are fairly numerous, Latin authors seem to have found their gastronomic qualities a more attractive theme than their natural history. Some, however, surprise us with the close and careful observation displayed by their remarks.

The credit of having been the first to lay out artificial oyster beds is commonly given to C. Sergius Orata. Orata was Praetor in 97 B.C., and was one of the most noted connoisseurs in the matter of oysters in his time. We read in Valerius Maximus that he closed the Lucrine Lake with extensive and lofty buildings, in order that the molluscs (conchylia) might always be obtainable in a fresh condition. The works undertaken by Orata were evidently necessary to preserve the tranquillity of the waters of the oyster grounds, because it is probable that in stormy weather the waves rolled right into the lake from the sea (Strabo). It is further recorded that Orata became involved in a lawsuit with one Considius, who held that the Lucrine waters had been leased to him by the State, whose property they really were.

Notwithstanding his lawsuit he derived, writes Pliny, great profit from the oysters which he grew in his "ostrearum vivarium," and which he advertised as the finest obtainable. It must be remembered that at that time Britain had not begun to supply the Roman market with the much-praised Rutupian* oysters.

In Pliny's day, oysters were brought by sea from Brundusium to the Lucrine, where they were fattened after their long voyage. Pliny unfortunately gives no details which might enable us to form some opinion of what an "ostrearum vivarium" was like, although he has plenty to say about the conditions favourable to their growth. He states that they like the fresh water of streams falling into the sea; in the open sea they are small and rare. They grow best at the beginning of summer, wherever the sunlight beats upon the bottom. If they cannot be reached by the sun's rays they grow more slowly and eat little for sadness. The best are found on firm ground, on rocks, not on sand or mud. They are not tolerant of being transplanted to other waters.

The only passage with which I am acquainted that may be construed as referring to the artificial cultivation of oysters on ropes, which will be described in detail below, occurs in the comparatively late author Ausonius, who flourished in the latter half of the fourth century A.D. Ausonius writes of oysters, *quae Baianis pendent fluitantia palis.* This to my mind means that at Baiæ the oysters hang swaying about in the waves on the stakes—an interpretation which agrees perfectly with the vase drawings to be described. Ausonius certainly could not have applied the word *fluitantia* to oysters lying immovable on the bottom of the sea.

Owing to the absence of any detailed description of artificial oyster cultivation as practised by the Romans, the two vase pictures have a unique archæological interest, and constitute the only real foundation for our knowledge of Roman oyster culture.

One representation (Fig. 1) occurs upon a glass vase, which was found at Piombino, the ancient Populonia, and was figured and described by Domenico Sestini, when it formed part of the collection of the Grand Duchess of Tuscany, Princess of Lucca di Piombino. The vase is almost globular, with a narrow tubular neck. Its height is 25 cm.; widest diameter 13 cm. The lower globular portion of the vase is decorated with a scene, which has been identified with the coast between Puteoli and Baiæ, as it existed in Roman times. It is not impossible that both this vase and others like it were sold at Roman watering-places to the visitors as mementoes of their holiday, just as similar topographical crockery is sold at our own seaside resorts to our more sentimental contemporaries.

---

* Richborough.

The Piombino vase bears a panoramic view of the chief buildings along a coast line. At one end of the picture is a pier carried on four arches jutting out over the water. Upon the pier are two columns, with birds, inscribed PILAE, and two arches bearing four sea-horses. At the land end is a building with four gables, a type very common in Pompeian frescoes. Then follow two large buildings, perhaps built on piles, and connected by a bridge beneath which are the OSTRIARIA. At the sides of the two large buildings and also behind the ostriaria are indications of waves. The vase bears the following inscription :—

ANIMA · FELIX · VIVAS

STAGNU · PALATIU P
I
OSTRIARIA RIPA L
A
E

If the scene be really a representation of a portion of the Bay of Baiæ and of the pier of Puteoli, the STAGNU referred to must be the Lucrine Lake.

The other vase (Figs. 2 and 3) is smaller, being less than half as high as the Piombino vase. It was originally described by De Rossi some forty years after Sestini had published the first, and is now in the Museo Borgiano di Propaganda Fede at Rome. It bears the inscription :—

MEMORIAE · FELICISSIMAE · FILIAE
FAROS · STAGNU · NERONIS · OSTRIARIA · STAGNU · SILVA · BAIAE.

Beneath the inscription are depicted several buildings, to the left of which is a reclining female figure holding two palm-branches in her right hand, and supposed by De Rossi to impersonate Baiæ.

To the right of this allegorical figure follow drawings of the objects specified in the inscription. The lighthouse (FAROS), pond or marsh (STAGNU(M) NERONIS), a wood (SILVA), and two buildings of similar architecture, with oyster-culture (OSTRIARIA) in between, are all represented.

The exact localisation of the scene is not an easy matter. Authorities are not agreed on the question whether the bit of coast lies to the south or east of Baiæ, nor even as to whether the view has been sketched from the sea or from the land. Those who support the last theory base their conviction on the fact that there are lines indicated between the houses, which they believe to represent waves of the sea as viewed by a spectator looking seawards. According to this theory the scene would have been situated to the south of Baiæ. The lighthouse (FAROS) might have been built on the site of the Fortino la Tenaglia, just beneath the hill on which Toledo's castle now stands; and the oyster-culture ground (OSTRIARIA) might have been in the shallows between the Fortino la Tenaglia and Baiæ, where at the present day from a boat many ruined walls can be seen below the clear water. On the other hand, it may be urged that if indeed the lines seen between the houses were meant to indicate water and not to be purely decorative, they might with equal truth represent the ripples of the Lucrine Lake seen from the sea, and their obviously artistic effect might have induced the artist to fill up his background with similar lines all round the vase.

Be the scene where it may, there can be no doubt that here we have a contemporary representation of Roman oyster cultivation not far from Baiæ.

Before proceeding to describe the ancient system of cultivation, a brief sketch of the modern system may facilitate the interpretation of the details shown none too clearly in the vase drawings. The method of culture employed at the present day in the Lucrine Lake is a method of *hanging culture*, as opposed to oyster culture in beds on the bottom.

The oysters are attached to coarse ropes, of loosely-twisted or plaited spartum grass, by being thrust between the strands (Fig. 6). These ropes, called *pergolari* at Taranto, are hung in the water from other ropes which are stretched horizontally between stakes driven into the mud at the bottom of the shallow lake. The tops of the stakes, and the horizontal ropes connecting them, are usually conspicuous objects on the surface of the water (Fig. 4). In the Mare piccolo, or inner harbour of Taranto, and in Lake Fusaro * (Fig. 5), a similar method of culture obtains. At Taranto the horizontal ropes are arranged so as to enclose quadrangular spaces, which are known as *sciaje*.

If we now turn to the OSTRIARIA as depicted on the vases, we find that the oysters and pergolari are shown as well as the perpendicular stakes, but that the modern horizontal ropes are replaced by more solid cross poles of wood. The ropes (*pergolari*) used for suspending the oysters were evidently of a very rough make, to judge from the inequalities represented in Fig. 1.

---

* For a description of the oyster culture of Lake Fusaro, see Coste's *Voyage d'exploration sur le Littoral de la France et de l'Italie.* Although he makes no statement to that effect, Coste's illustrations (cf. Figs. 9-12) would lead one to suppose that the round objects hanging from the framework of the Roman ostrearia were intended to be baskets of oysters similar to those in use at the present day, both in Lake Fusaro and in the Lucrine, in addition to the ropes of the larger oysters. This interpretation may apply to the Piombino vase-picture, although even there the ropes project beyond the round objects, but does not, I think, agree with the Borgiano vase-picture so well as the one advanced above. My thanks are due to Mr. E. J. Allen for drawing my attention to Coste's memoir.

The structure of the framework is rather difficult to make out. The drawings were apparently intended to show both the front elevation and the top view of the framework. In the Borgiano vase (Fig. 2) the framework is quite regular, and consists of four bars crossing five others at right angles (cf. the *sciaje* of Taranto). At the intersection of the bars a number of lines are drawn which may possibly represent either pegs or cord lashings used to fix or tie the bars together. The horizontal framework was supported by a number of vertical posts. Of these four are represented, and between them are shown three ropes with three oysters each. On the right-hand side is another similar rope of oysters, and above it two bars crossing, which were probably used to strengthen the fabric.

On the Piombino vase (Fig. 1) the picture of the ostrearium probably represents a similar view. The ostrearium lay between two houses and under a bridge—an arrangement analogous to that of the oyster cultivation of Lake Fusaro, accidentally shown in a photograph taken by myself (Fig. 5). Here, too, the end of the bridge abuts on an isolated building, the pleasure-house constructed by Ferdinand I. (not shown in Fig. 5). The poles for the oysters may be seen projecting above the water both beyond and under the bridge. In the Piombino vase the cross-bars of the framework are not arranged with such regularity as on the Borgiano vase.

In conclusion, the object of the present communication is to demonstrate that the only type of artificial oyster culture of the ancient Romans, of which we have an adequate knowledge, was the method of hanging rope culture, which still continues to exist at the the same spot, viz. the Lucrine Lake and its neighbourhood, and in an almost identical manner. Even the importation of oysters into the Lucrine is similar. At the present time they are brought from Taranto. In the days of the Romans, according to Pliny, they were imported from Brundusium.

REFERENCES.

Ausonius, D. M.—*Epistolae*, ix. 30.

Beloch, J.—*Campanien.* Breslau. 1890.

Coste, P.—*Voyage d'Exploration sur le Littoral de la France et de l'Italie.* Deuxième Edition. Paris. 1861.

Maximus, C. Valerius.—Lib. ix. 1.

Plinius, C.—*Historia Naturalis.* Lib. ix. 54 and 79; lib. xxxii. 21.

Rossi, G. B. de.—*Topografia delle spiagge di Baja graffita sopra due vasi di vetro.* Bulletino Archeologico Napolitano, n.s. I., No. 17, tav. ix. 1853.

Servius, M.—*Commentarius in Verg. Georg.* ii. 161.

Sestini, D.—*Illustrazione d'un vaso antico di vetro ritrovato in un sepolcro presso l'antica Populonia.* Firenze. 1812.

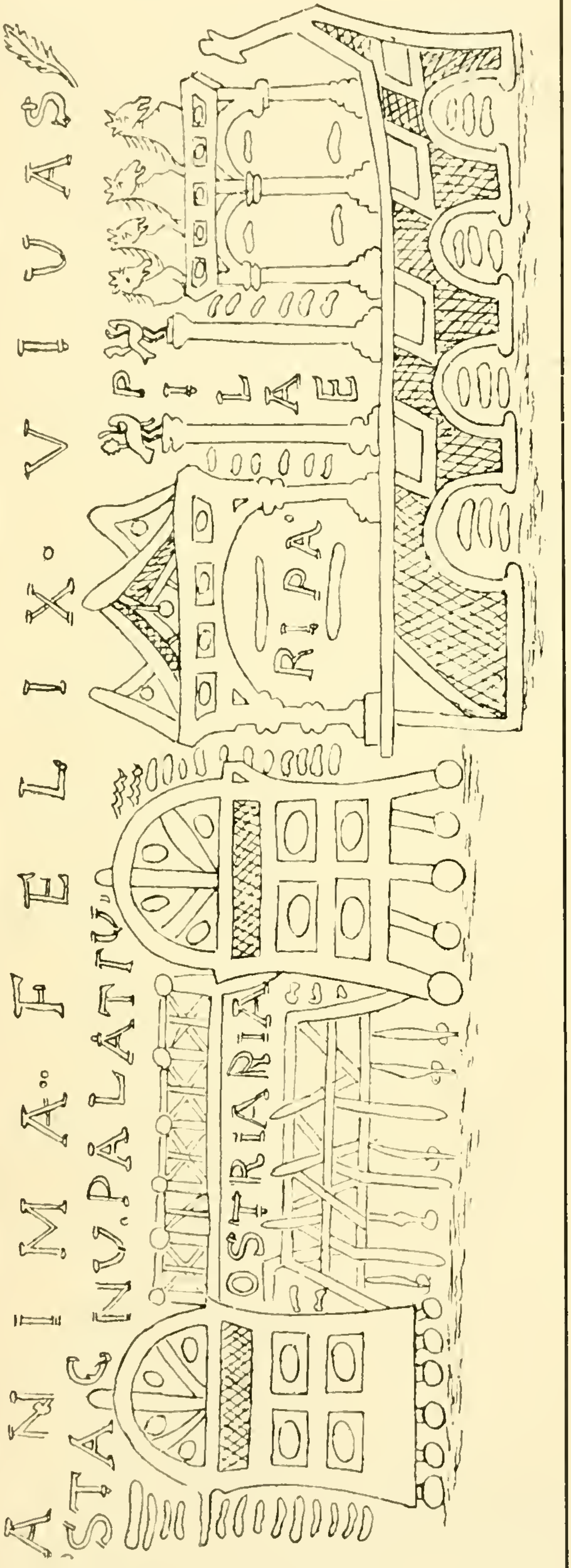

ANIMA · FELIX · VIVAS
STAGNV · PALATIV
OSTRIARIA
RIPA
PILAE

Fig. 1.

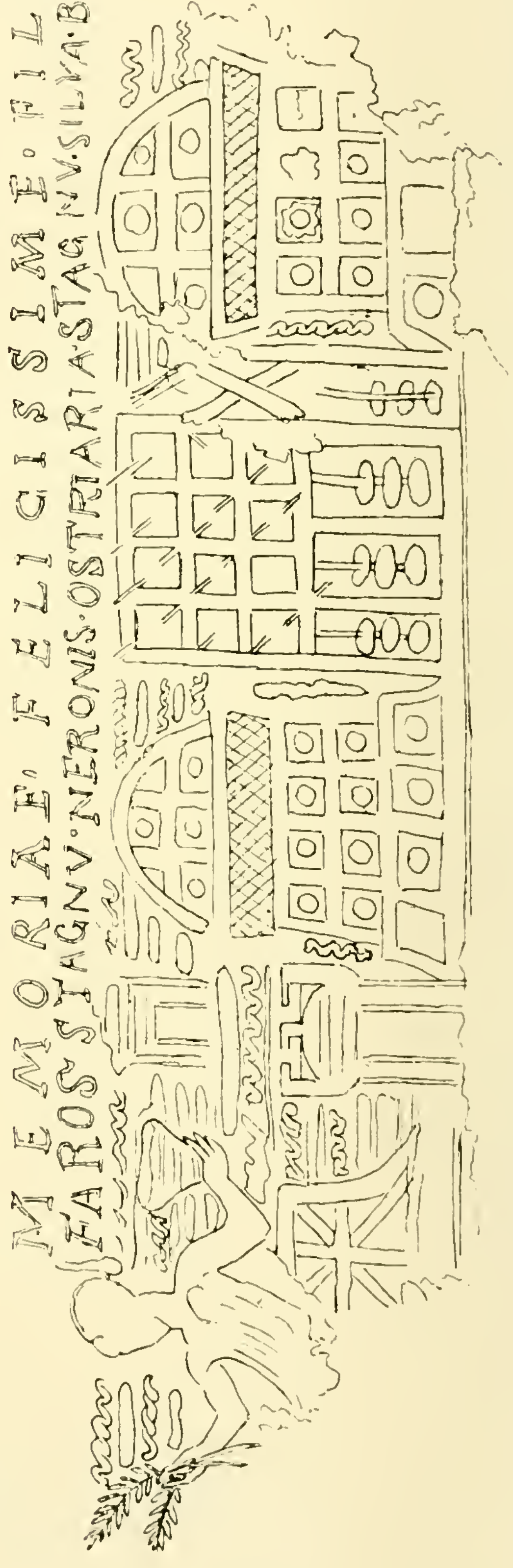

MEMORIAE · FELICISSIMAE · FILIAE
FAROS · STAGNV · NERONIS · OSTRIARIA · STAGNV · SILVA · BAIAE

Fig. 2.

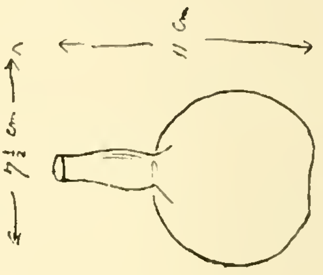


Fig. 3.

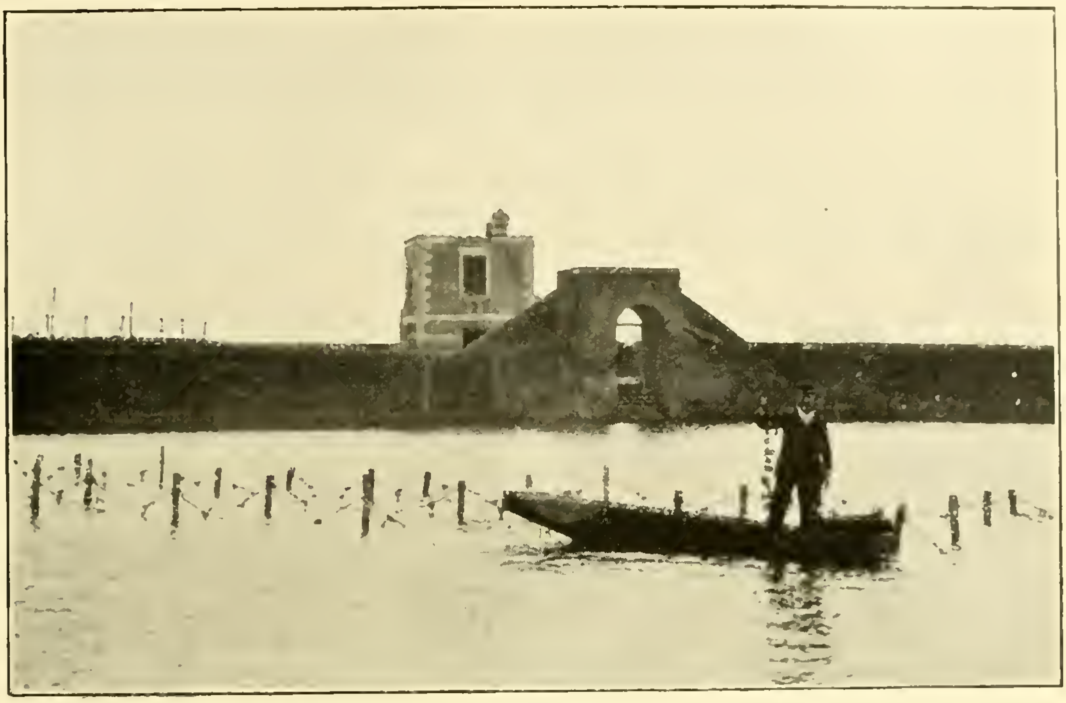


Fig. 4.

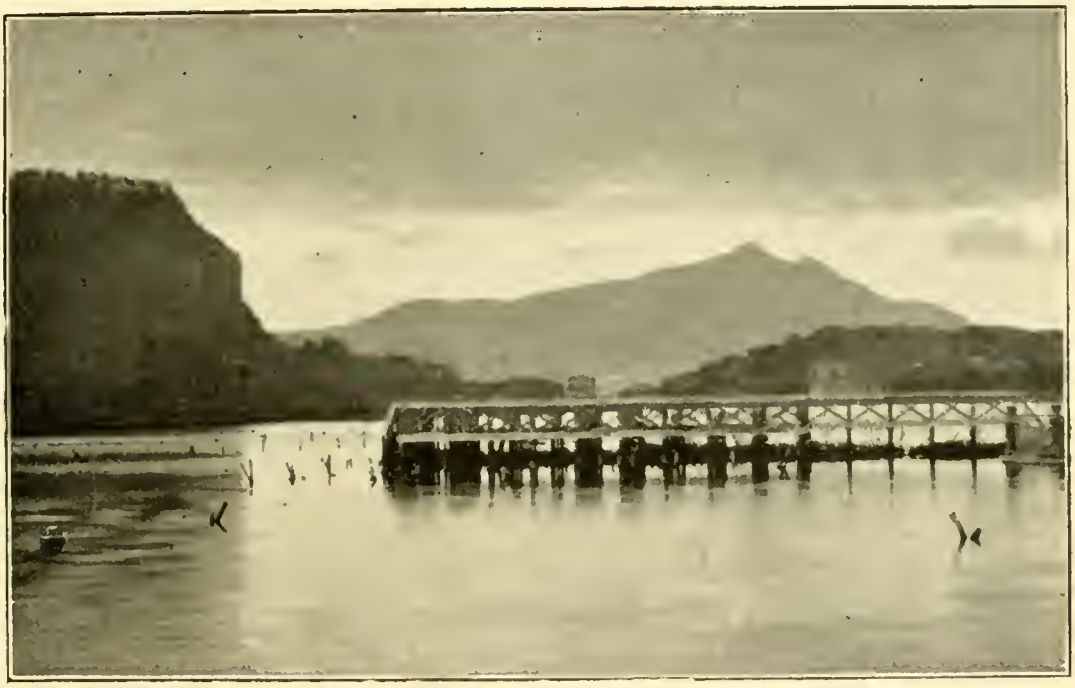


Fig. 5.

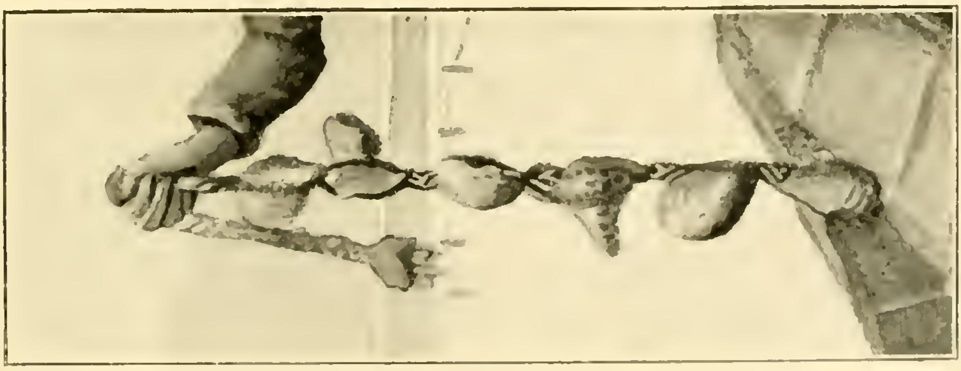


Fig. 6.

EXPLANATION OF PLATE 1.

Illustrating Mr. R. T. Günther's Paper on "The Oyster Culture of the Ancient Romans."

Fig. 1.—OSTRIARIA beneath a bridge connecting the upper stories of two buildings, similar to those represented in Fig. 2. One oyster is shown attached to each rope. To the right is a pier. Piombino vase. After De Rossi.

Fig. 2.—OSTRIARIA and buildings near Baiae. Three oysters are attached to each rope. The ropes hang from a framework, as in Fig. 1. Borgiano vase. After De Rossi.

Fig. 3.—Glass vase. Museo Borgiano.

Fig. 4.—Oyster culture in Lucrine Lake. The man in the punt is shown holding up a rope of oysters (cf. Fig. 6), which he has just detached from the cross-ropes between the posts.

Fig. 5.—View of Lake Fusaro, showing the upper ends of the posts used to support the oysters. On the left is the steep profile of the Monte di Procida. The volcanic peak in the distance is Mont' Epomeo in Ischia.

Fig. 6.—Rope with oysters (*pergolaro*), showing mode of insertion between the strands. I am indebted to Mr. C. Hallett for this sketch from my photograph.

Recent Reports of Fishery Authorities.

The Scottish Report for 1895.

Fourteenth Annual Report of the Fishery Board for Scotland, being for the year 1895. *Edinburgh*, 1896.

THE EFFECT OF THE CLOSURE OF INSHORE AREAS UPON THE SIZE AND ABUNDANCE OF THE FOOD-FISHES WHICH THEY CONTAIN.—In the Report under consideration Dr. T. Wemyss Fulton, the Scientific Superintendent of the Scottish Fishery Board, publishes an important Review of the Trawling Experiments of the *Garland* in the Firth of Forth and St. Andrews Bay in the years 1886–1895. As is well known, these areas have been closed to trawlers during the ten years under consideration. The Board's steamboat *Garland* has from time to time made experimental hauls with a 25 ft. beam-trawl along certain fixed lines within the areas, the fish captured being measured and recorded, and the results of the experiments published from year to year in the Reports. After ten years' work, Dr. Fulton now gives a general review of the whole investigation, and indicates the conclusions to which, in his opinion, the results of the experiments seem to point.

The views expressed are of so much importance that we prefer to give the account of the manner in which the observations were recorded, and the summary and general conclusions, in Dr. Fulton's own words:—

"In conducting the trawling experiments the aim has been, as far as possible, to trawl over each station at intervals of about a month, and to keep careful records of each haul, and of the conditions under which it was made. The regular trawling work has been done only in the day-time . . . . The observations at each station comprised (1) the date and hour of the haul and its duration; (2) the temperature of the air and of the water at surface and bottom; (3) the density of the water at surface and bottom; (4) the transparency of the water, as indicated by the depth at which an enamelled disc just ceased to be visible; (5) the direction and force of the wind, the state of the tide, the condition of the weather and of the sea in regard to surface disturbance, and the height of the barometer — the temperature, density, and other observations being taken at the beginning and at the end of the trawling; that is to say, at each end of the station; (6) the nature of the pelagic fauna, collections being made by means of tow-nets at surface and bottom, and occasionally at intermediate depths; (7) the number of each species of fish, and the length of each individual caught in the trawl; (8) the nature and relative abundance of the invertebrate organisms found in the trawl, which form a large portion of the food of the bottom-living fishes."

"SUMMARY AND CONCLUSIONS.

"While the trawling experiments of the *Garland* in the Firth of Forth and St. Andrews Bay have been productive of a great body of scientific knowledge respecting the reproduction, spawning areas, and the natural history generally of the food-fishes, the immediate practical object in view was to ascertain the influence which the cessation of beam-trawling would have upon the relative abundance of the food-fishes within the closed areas. The method adopted for this purpose has been already explained, namely, the periodic examination of certain selected stations in each of the areas, the enumeration and measurement of the fishes caught, and the comparison of the statistics thus obtained from month to month and year to year. A question which confronts one at the outset is whether the period during which the experiments have been carried on is sufficiently long to enable definite conclusions to be formulated with certainty. It is evident, on the one hand, that if trustworthy conclusions in regard to the influence of beam-trawling can be drawn from the ten years' experiments in the Firth of Forth and St. Andrews Bay, it is unnecessary that they should be continued there. On the other hand, it would be obviously unwise to terminate them until definite conclusions are obtained, since so much depends upon them.

"The problem is complex, inasmuch as the natural causes, which are of course by far the most important in producing fluctuations in the abundance of the food-fishes in any given area, are very variable and very obscure. There is in the first place the group of physical influences, such as the weather, storms, currents, and temperature, acting directly upon the fishes themselves at all stages of their life, from the floating egg onward to the adult condition, and upon the organisms upon which they feed; and in the second place, a group of biological causes, such as variations in reproductive activity, migrations from the closed area to the outer waters, and *vice versa*, and the presence, or absence, of other fishes upon which particular species feed, *e.g.*, the herring. For example, it was discovered by the fine-meshed nets of the *Garland* that in the autumn of 1889 a vast shoal of young whiting —computed after careful observations to number over 200,000,000— was present in the Firth of Forth. They were too small to be caught that year in the ordinary net used in the trawling experiments, and the average for that year was not large. But in 1890 the average number rose in the closed waters of the Forth from 13·6 to 56·9, and in the open waters from 19·9 to 121·6; and the fishermen in the district caught very nearly double the quantity of whitings that they did in 1889. This increase in the abundance of whitings was local, and may have been due to a combination of causes. Another example was the sudden and extraordinary abundance of small haddocks all along the east coast of Scotland in 1893. In the Firth of Forth the average sprang up from 22·1 to 118·8 in the closed waters (over 1000 being sometimes taken in a haul), and in the open waters from 42·4 to 176·3; and in the closed waters of St. Andrews Bay the average rose from 1·0 to 23·8, and in the open area from 8·8 to 43·8.

"These instances will suffice to show how sudden and marked the natural fluctuations may be, and how they tend to obscure the influence of a minor though constant factor, such as a mode of fishing. The answer to the question as to how long it is necessary to continue the observations in the Firth of Forth and St. Andrews Bay depends to a large extent upon the continuity of the results underlying the variations, as determined by a comparison of the averages in the first and second parts of the period during which they have been carried on. From the statistical analysis given in the foregoing pages, and summarised below, it appears to be fairly well proved that there has been a diminution of the more important flat-fishes in the closed waters, instead of an increase, as was anticipated; and that this may probably be traced to the influence of beam-trawling in the open waters where the fishes spawn; but with regard to round-fishes, which are more numerous and migratory, the same conclusion cannot at present be drawn. In my opinion, after full consideration of the question, the best course is in the meantime to suspend the trawling experiments in the Firth of Forth and St. Andrews Bay, and to carry them on systematically in the Firth of Clyde and the Moray Firth. Both of these areas contain within the closed limits extensive spawning grounds (which are absent from the Firth of Forth and St. Andrews Bay) that are frequented by successive shoals of the food-fishes at the spawning time; and it is of great importance to ascertain the effect of the protection of these spawning places.

"The statistics of the ten years' observations in the Firth of Forth and St. Andrews Bay point to the following conclusions:—

"1. No very marked change has taken place in the abundance of the food-fishes generally within the closed or open waters since the prohibition of trawling. The average number of the food-fishes (taken together) caught in each haul of the net in the years 1886–1890 was 242·6 in the closed waters of the Forth, and 160·9 in the open waters; in the closed waters of St. Andrews Bay the average was 290·2, and in the open waters 190·4. In the five years 1891–1895, the general averages were 252·8 for the closed area of the Forth, and 171·7 in the open area; for the closed area of St. Andrews Bay the average was 184·5, and for the open area 182·7. There was thus a decrease in both areas of St. Andrews Bay, and an increase in both areas of the Forth.

"2. Among round-fishes, cod increased in numbers in all the areas, closed and open. Haddocks increased in the closed and open areas of the Forth, and in the open waters of St. Andrews Bay, and decreased in the closed waters of St. Andrews Bay. Whitings decreased in abundance in all the areas, and gurnards increased in the closed waters of the Forth, and decreased in the other three areas.

"3. Flat-fishes, taking the different kinds together, increased in the open waters of St. Andrews Bay, and decreased in all the other areas. Plaice decreased in all the areas to the extent of 8·7 fishes per haul of the net in the closed waters of the Firth of Forth, and no less than 74·9 fishes per haul in the closed waters of St. Andrews Bay; in the open waters of St. Andrews Bay the decrease was 23·1 fishes per haul, and in the open waters of the Forth, where they are scarcer, 0·6 per haul. Lemon soles, in like manner, diminished in abundance in all the areas—to the extent of 8·4 fishes per haul of the net in the closed area of the Firth. In the other areas, where they are much scarcer, the decrease was less striking. These are the most important and valuable of the flat-fishes obtained: turbot and brill were not caught in sufficient numbers to enable an average to be usefully calculated. On the other hand, the common and abundant dabs, commercially of little importance, increased rather than diminished in numbers. The common dab increased in the closed area of the Forth by 8·9 fishes per haul, and in the open area of St. Andrews Bay by 29·3 fishes per haul; they decreased in the closed area of St. Andrews Bay by 20·3 fishes per haul, and in the open waters of the Forth by 2·1 per haul. The long rough dab increased in all the areas, except in the closed area of St. Andrews Bay, where they are very scarce, the decrease there being 0·5 per haul. In the closed waters of the Forth their increase amounted to 6·2 fishes per haul, and in the open waters to 4·9 per haul; in the open waters of St. Andrews Bay the increase was 3·3 per haul.

"These facts in connection with the relative abundance of flat-fishes are of importance. On the face of it, it appears strange that there should have been a fairly continuous decrease in the numbers of plaice and lemon soles in the closed waters throughout the period. Fluctuations have undoubtedly occurred from year to year, but, as has been frequently pointed out in previous reports, the statistics show a fairly steady falling off in the abundance of the species; and of such a character, when compared with the variations of other species, as to preclude the idea that it is due to the operation of natural causes. It was naturally expected that the prohibition of the use of the beam-trawl in the Firth of Forth and St. Andrews Bay would be followed by an increase and not by a decrease in the numbers of these species within the closed area, because the beam-trawl is the most effective fishing instrument by which they are captured, and its interdiction was equivalent to the removal probably of their greatest enemy.*

"But such has not been the case. Before dealing with the probable cause of the falling off among plaice and lemon soles attention may be directed to the increase in the numbers of common dabs and long rough dabs, which may be said to have taken the place to some extent in the closed waters of the more valuable flat-fishes. Taking the figures for the closed area of the Firth of Forth as the result of 574 hauls of the net during the ten years, the decrease in the number of plaice caught per haul of the net is found to have been 8·7, and of lemon soles 8·4, a decrease almost exactly counterbalanced by the increase in common dabs, which was 8·9, and in long rough dabs, which was 6·2. This clearly indicates a change in the relative proportion of the flat-fishes in the area, from whatever cause arising. Now there are some important differences in this connection between the dabs on the one hand, and the plaice and the lemon soles on the other. The dabs become mature while still comparatively small, and escape in great numbers through the meshes of an ordinary trawl net, and they spawn to a large extent in the closed waters. Plaice and lemon soles, on the contrary, do not spawn within the closed waters, and immature individuals are caught in great numbers by the ordinary trawl net. Thus the size at which common dabs and long rough dabs become mature is about 5 inches—the males frequently at a smaller size—while plaice do not become mature until they are 13 or 14 inches long, and lemon soles not until they reach a length of 9 or 10 inches.*

---

* "The proportion of the fish present in a given area that may be captured by fishing apparatus is frequently under-estimated. Of several thousands of plaice, marked for future identification and returned living to the closed waters, about 12 per cent. were subsequently recaptured and returned to me within 18 months—and mostly within a few months—of their liberation. They were nearly all retaken in the closed waters by hook; and as there is no reason to suppose that the marked fish were more prone to seize the bait than the fish around them which had not previously been captured, it may be assumed that at least 1 in 9 or 1 in 10 of the plaice living on an area fall victims to the hook of the fisherman. With the beam-trawl the proportion would have been very much greater.—*Vide* 'An Experimental Investigation on the Migrations and Rate of Growth of the Food Fishes,' Part III., *Eleventh Annual Report*, p. 176."

"The consequence of this difference in the length when sexual maturity is first reached in the two groups is that all adult plaice and lemon soles, and large numbers which have not yet reached maturity, which enter an ordinary trawl net, cannot escape through the meshes, and are captured; while large numbers of adult dabs of both species, and by far the greater proportion of the immature, do escape through the meshes of the net, and are therefore not caught. In other words, the ordinary beam-trawl is not anything like so destructive to dabs as to plaice and lemon soles. The special experiments made on the *Garland* bring out this matter in a marked manner.†

"Thus in 43 hauls of the *Garland's* ordinary net, having meshes in the cod-end of 1½ inches from knot to knot, 2705 plaice of all sizes were retained in the net, and only 67 escaped through the meshes; among lemon soles 371 were retained, and 154 escaped; among common dabs 3367 were retained and 9892 escaped; and among long rough dabs 506 were retained, and 2562 passed through the meshes. Of the 67 plaice which escaped, 59 were 7 inches or less in length, and only 8 above that size (8 inches); of the 154 lemon soles none were above 7 inches; of the 9892 common dabs which found their way out of the net, 2086 were 6 inches or over—that is to say, of adult size—and 5426 were 5 inches in length, or about the size at which maturity is reached; of the 2562 long rough dabs which escaped, 1238 were 5 inches or over.

"The other point is also of importance, namely, the place where the fishes spawn; and the information on this subject obtained by the *Garland* is of great value.‡ The plaice and the lemon sole spawn outside the territorial waters, and therefore beyond the limits of the closed areas. All the plaice and almost all the lemon soles in the Firth of Forth and St. Andrews Bay come in from the outer waters, their floating pelagic eggs, or their equally helpless larvæ, being borne in by the currents; or some may have migrated thither at a later stage. The abundance of these forms in the closed areas is therefore strictly and directly dependent on the outer seas. It is not the same with the dabs. They seem to spawn indifferently in the closed and in the open waters, although spawning individuals are rather more numerous in the latter.

---

* "*Vide* 'Observations on the Reproduction, Maturity, and Sexual Relations of the Food-Fishes,' Part III., *Tenth Annual Report*, p. 232."

† "*Vide* 'The Capture and Destruction of Immature Sea Fishes,' Part III., 'The Relation between the Size of the Mesh of Trawl Nets and the Fish Captured,' Part III., *Twelfth Annual Report*, p. 302."

‡ "*Vide* 'The Spawning and Spawning-Places of Marine Food-Fishes,' Part III., *Eighth Annual Report*, p. 257; also Part III., *Tenth Annual Report*, p. 235."

An area like the Firth of Forth is therefore, to a very large extent, independent of the outer seas so far as concerns its supply of dabs, it being in large measure self-productive.

"The differences above described between the plaice and lemon soles and the dabs seem to furnish a reasonable explanation of their decrease and increase respectively. When beam-trawlers were prohibited from working in the Firth of Forth and St. Andrews Bay, they naturally concentrated their efforts in the free waters outside, and trawling operations there have very greatly increased since the Bye-laws were passed. The immediate consequence of the cessation of trawling in the Firth of Forth and St. Andrews Bay appears to have been an increase in the abundance of flat-fishes within the closed areas, as shown by the very high averages in the year 1887. The fact that this increase was not only not maintained, but that a progressive decrease in plaice and lemon soles occurred subsequently, indicates another influence, namely, excessive trawling on the offshore grounds where these fishes spawn. This would affect the abundance of the important flat-fishes, such as plaice and lemon soles, in two ways. By general overfishing, the numbers are decreased on the fishing-ground, as indicated by the averages for the open area; and in the second place, by the removal of too great a proportion of the mature spawning fishes, the supply of floating eggs and larvæ to the inshore closed areas, and upon which they are dependent, is diminished below the normal, with the result that the supply of adults is also subsequently diminished. This appears to me to be the only feasible explanation of the facts stated, and it would indicate protection of the spawning areas as the proper course to be pursued. The protection of the immature fishes, which has been so strongly advocated by many authorities, will not, it can be safely said, be sufficient in the areas under consideration. This is clearly proved by the fact that the fish which, above all others, has the nurseries of its young located in the inshore waters is the plaice. The distribution of immature plaice is special in this respect, by far the largest number being got near the shore, and fewer and fewer the further from the shore.* In the Firth of Forth and St. Andrews Bay immature plaice have therefore been particularly well protected since 1886, and yet this is the species whose diminution is most marked.

"The results of the trawling experiments hitherto conducted in the Firth of Forth and St. Andrews Bay point to two main conclusions of great importance for fishery regulations. One, which may be regarded as demonstrated, is that the mere closure of even large areas in the territorial waters, such as the Firth of Forth and St. Andrews

---

* "*Vide* 'The Distribution of Immature Sea Fish and their Capture by various Modes of Fishing,' Part III., *Eighth Annual Report*, p. 166."

Bay, which are destitute of spawning-grounds, will have little or no permanent effect in increasing the abundance of the important food-fishes, and especially the flat-fishes, within them. The other, which, although highly probable, has not yet been actually demonstrated by experiment, is that protection of the offshore spawning-grounds for certain periods is the most likely method of increasing the abundance of the fishes in the inshore waters. In completion of the experiments in the Firth of Forth and St. Andrews Bay, it would be desirable if a part at least of the offshore waters from which the supplies of floating eggs and larvæ to these areas are drawn were closed during the spawning season. It would then be possible to ascertain, by comparison of the results with those already obtained, to what extent protection of spawning areas will lead to an increase in the fish supply within the territorial waters. The extent and situation of the offshore areas which stand in this direct and close relationship to a given portion of the territorial waters have not yet been satisfactorily determined; but experiments are now being made to clear up this point."

THE DUNBAR HATCHERY.—Mr. Harald Dannevig gives an account of the working of the Marine Hatchery at Dunbar during 1895. Three species, the turbot, the lemon sole, and the plaice, were dealt with. As in previous years, the great difficulty has been in obtaining a sufficient supply of spawning fish in a healthy condition. In the case of the turbot, the supply consisted of thirty-four fish, which had to be brought to Dunbar from Girvan on the west coast, and no natural spawning took place. Eggs were, however, pressed from the ripe fish and successfully fertilised. About 3,800,000 larval turbot were hatched and distributed in the neighbourhood of Dunbar.

Less difficulty was experienced with the lemon soles, which, when they reached the hatchery uninjured, spawned naturally. About 4,480,000 fertilised eggs were obtained during the season from a stock of sixty-eight healthy fish, and from these 4,145,000 larvæ were successfully hatched out and distributed in the local waters and westwards as far as the Bass Rock, the loss of eggs during development being thus only 7·5 per cent.

In the case of the plaice again it was found necessary, in order to ensure a good supply of eggs, to press them from the ripe females and artificially fertilise. In this way 14,970,000 eggs were obtained, and from them 11,350,000 larvæ were hatched. About 7,000,000 of these larvæ were distributed in the North Sea in the neighbourhood of Dunbar. It was considered advisable, however, to test, if possible, the effect produced by thus placing large numbers of newly-hatched larvæ in the sea, and in order to do this it was determined to attempt to place them in a more or less confined area. For this purpose Loch

Fyne, on the west coast of Scotland, was selected, 4,000,000 larvæ being conveyed there by train in four separate consignments. The transport appears to have been fairly successful, though on two occasions the larvæ are reported as showing a certain amount of weakness when put out in the loch. This difficulty will no doubt be got over after further experience in the best methods of transport has been gained.

THE OYSTER BEDS OF THE FIRTH OF FORTH.—Dr. Fulton contributes a second valuable paper to the Report, in which he discusses the past and present condition of the oyster beds in the Firth of Forth. The causes of the exhaustion of the beds are considered, and various suggestions made as to the measures which should be adopted in order to make them again productive. Dr. Fulton considers that the present condition of the beds is entirely due to improper fishing and the neglect of efficient regulations; and further, that there is still a chance of restoring at least a part of them by judicious aid. The measures recommended are (1) the laying down of a stock of oysters to furnish spat; (2) the supply of suitable cultch for the reception of the spat; and (3) keeping the ground clean and as free as possible from enemies. As no oysters are so suitable for any locality as the oysters which naturally live there or in the neighbourhood, by far the best means of obtaining the breeding stock would be to collect the oysters at present scattered over the beds, and to lay them down in one or more selected places. This might be done by purchasing from the fishermen the oysters taken when dredging for mussels and clams. The oysters thus obtained for breeding purposes might be supplemented by others obtained elsewhere.

In order to obtain a supply of clean cultch for the spat to settle upon, mussel and clam shells might be collected from the various villages and exposed to the sun and air until the spatting time, when they should be strewn on the various grounds. Dr. Fulton calculates that an expenditure of £600 per annum for five or six years would be sufficient to carry out the scheme he recommends, including the protection of the areas where the breeding stock was deposited. On the other hand, the fishermen on the south side of the Firth of Forth have lost during the last twenty years fully £150,000 by the exhaustion of the beds, to say nothing of the loss to the citizens.

RATE OF GROWTH OF THE HERRING.—Mr. Masterman's paper, "On the Rate of Growth of the Food-Fishes," deals with the rate of growth of the Herring at St. Andrews, and the author gives the following summary of his conclusions:—"The young larva, hatched at from 5 to 7 mm. ($\frac{2}{10}$ inch) in length, lives near the bottom till some 10 mm. ($\frac{4}{10}$ inch) is attained by a rapid increase in length. The attenuated post-larval herring then migrates upwards through the mid-water to the surface, the mid-water stage lasting from about 10 mm. ($\frac{4}{10}$ inch) to

23–24 mm. ($\frac{9}{10}$ inch), and the surface stage from 24 mm. to 27–28 mm. (about 1 inch), when a movement shorewards takes place, and the littoral habit is acquired." The young herring of the spring-spawning remain near shore, chiefly at the mouths of rivers, until mid-winter, when the length of some 50 mm. (2 inches) has been reached. They are not found during the spring and summer, but recur in the same localities in the autumn with a length of about 80 mm. ($3\frac{1}{5}$ inches), which is increased to 100 mm. (4 inches) by the end of the year.

OTHER PAPERS.—Dr. J. H. Fullarton contributes a memoir on the European Lobster, in which he deals chiefly with the breeding and development of that animal. His results agree in the main with those obtained by Ehrenbaum in Heligoland, a full account of which was given in this Journal, vol. iv. pp. 60–69. A series of figures is given, showing the external appearance of the embryos and larvæ at various stages of development.

Amongst the other papers may be mentioned Professor M'Intosh's "Contributions to the Life-Histories and Development of the Food and other Fishes," and Mr. Thomas Scott's faunistic papers, dealing with the Firth of Forth, the inland waters of Scotland, and the inland waters of the Shetland Islands.

The Danish Report.

Report of the Danish Biological Station to the Home Department. *V.* 1894. *By C. G. John Petersen, Ph.D., Copenhagen,* 1896.

THE BRIDAL-DRESS OF THE COMMON EEL.[*]—Dr. C. G. J. Petersen's paper—"The Common Eel (*Anguilla vulgaris, Turton*) gets a particular breeding-dress before its emigration to the sea. The bearings of this fact on the classification and on the practical Eel-fisheries"—forms an important contribution to the solution of the mystery which has surrounded the life-history of the eel, and serves to complete the brilliant observations of Professor Grassi, an account of which was given in this Journal two years ago by Mr. Cunningham.

Three different kinds of eel have been recognised both by fishermen and naturalists. Thus Yarrel distinguishes three species, the sharp-nosed eel—silver eel of the fishermen—(*Anguilla acutirostris*), the broad-nosed eel—grig or frog-mouthed eel of fishermen—(*Anguilla*

---

[*] On this subject compare also Professor G. B. Grassi, "The Reproduction and Metamorphosis of the Common Eel (*Anguilla vulgaris*)." *Proceed. Roy. Soc. London*, No. 363, December, 1896. An account of Grassi's observations is given by Cunningham, "The Larva of the Eel," *Journ. Mar. Biol. Assoc.*, vol. iii. pp. 278–287.

latirostris), and the snig or yellow eel (*Anguilla mediorostris*). Later authors have, for the most part, regarded the three kinds as varieties of one species, *Anguilla vulgaris*. Günther, however, in his *Catalogue of the Fishes in the British Museum*, attempts to distinguish two species, *A. vulgaris* and *A. latirostris*, the latter being the frog-mouthed or broad-nosed eel of Yarrel.

In the Report now under review Petersen regards the three so-called varieties as representing three stages in the development of one and the same animal, and his conclusions, based upon a large number of carefully-considered observations, appear to be well founded. Briefly stated the result arrived at is, that the yellow eels comprise both males and females, but are all young fish, which have not yet commenced to assume the bridal-dress of the adult, and in which the generative organs are little developed. The frog-mouthed eels are larger females still in the same conditions, whilst the silver eels comprise both males and females which have taken on the bridal-dress. The generative organs of the latter class are more fully developed, and the animals just on the point of migrating to the sea to spawn.

The following more detailed account of the three kinds of eels is derived from that given by Petersen.

YELLOW EELS.—The yellow eels are generally of rather light colour, the back, for instance, being grey or brownish, often with a greenish shade, the sides pale yellow, and the belly either like the sides or of a pure white. They are found in both salt and fresh water, and are taken during the winter as well as in summer. The digestive organs are well developed, and the eels feed voraciously. The snout in front of the eyes is much flattened; the eyes are small, the interorbital space being greater than the horizontal diameter of the eye—in larger specimens generally about double the size. Looked at vertically from above the eyes face upwards rather than sideways, and the corners of the mouth, with the lips, can be seen distinctly outside the eyes. The pectoral fins are light in colour and rounded posteriorly. The skin is thin, the scales are but slightly visible, and very little *guanine*, which gives the metallic, silvery look to the silver eels, is deposited. The lateral line and its branchings can be seen, but not very distinctly. The yellow eels comprise both males and females, but there are no good external characters to distinguish the sexes excepting size, the males being never longer than 48 cm. (19 inches), whilst the females can reach $\frac{1}{2}$ to 1 metre (20 to 40 inches). The generative organs are but little developed in either sex, although they are sufficiently so to make it quite possible to distinguish males from females, without microscopic examination, in specimens 10 inches long and upwards. With the aid of the microscope the sexes may be distinguished by an examination of the reproductive organs in specimens down to 8 inches. Below this size the distinction is impossible.

Frog-mouthed Eels.—These are really the same as the yellow eels, excepting that they are much larger and are all females. They are large females, with ovaries as yet but little developed, and which have not commenced to take on the breeding-dress. Their bodies are long and lean, and they feed voraciously. The pectoral fins are light coloured and rounded behind. The heads appear large in proportion to the bodies, and possess the same characters as the heads of the yellow eels in a more exaggerated form. These large, lean fish appear in numbers at the beginning of summer, having probably been starving during the winter. They are caught in large numbers on hooks baited with fish, and their stomachs are often much dilated with food. Later in the year they become less frequent, having become fat and taken on the breeding-dress.

Silver Eels.—These are yellow eels, which have assumed the breeding-dress, and are about to migrate to the sea to breed. The author has observed all transition stages between yellow and silver eels, and yellow eels with commencing metallic lustre kept in caufs he has frequently observed transformed in a few weeks into silver eels.

Silver eels are all of large size, and comprise both males and females. No males have been found under 29 cm. (11½ inches) long, and they are rare at this size. The smallest female observed was 42 cm. (16½ inches) long, but these also are seldom seen so small. The bodies of the silver eels are plump and fat. The snout in front of the eyes, particularly in the males, is high and a little compressed, probably owing to the considerable development of the olfactory organs and an increase in the size of the eyes. When the head is looked at vertically from above, the eyes protrude beyond the lips, and face sideways or outwards rather than, as in the yellow eels, upwards. The eyes are also considerably larger than in yellow eels of the same length. This was proved both by measuring and weighing eyes from the two kinds. The colour of the back is dark, nearly black; there are bronze streaks at the sides, and the ventral side is silver-white with a metallic lustre. The pectoral fins are dark coloured, even black, pointed behind, and longer in proportion to the head than those of the yellow eels, which are bright coloured and rounded. The skin of the body is thick and firm, the outlines of the scales distinct, and the lateral line, with its ramifications, easily seen.

The silver eels do not feed much, and are seldom caught on hooks. The digestive organs are comparatively much smaller than those of yellow eels, as the author has proved by weighing them, whilst the reproductive organs of both males and females are in a much more advanced condition. The silver eels emigrate from the rivers to the sea in summer and autumn, and are caught in traps, the mouths of which are set to face up-stream. In winter all the eels caught are yellow eels.

Petersen points out that, in consequence of the above relations between the different kinds of eels in closed waters or rivers, where all the silver eels can be caught as they emigrate to the sea, the yellow eels should not be taken at other times, but allowed to remain until they become silver eels of larger size and greater value.

In confirmation of Petersen's views, and in order to complete the history, we may add the following quotation from Grassi's most recent paper in the *Proceedings of the Royal Society**:—

"In another point my researches have yielded a very interesting result. As a result of the observations of Petersen, we know now that the common eel develops a bridal coloration or 'mating habit,' which is chiefly characterised by the silver pigment without trace of yellow, and by the more or less black colour of the pectoral fin, and finally by the large eyes. Petersen inferred that this was the bridal coloration from the circumstance that the individuals exhibiting it had the genital organs largely developed, had ceased to take nourishment, and were migrating to the sea. Here Petersen's observations cease and mine begin. The same currents at Messina, which bring us the Leptocephali, bring us also many specimens of the common eel, all of which exhibit the silver coloration. Not a few of them present the characters described by Petersen in an exaggerated condition; that is to say, the eyes are larger and nearly round instead of elliptical, whilst the pectoral fins are of an intense black. It is worth noting that in a certain number of them the anterior margin of the gill-slit is intensely black, a character which I have never observed in eels which had not yet migrated to the sea, and which is wanting in the figures and in the originals sent to me by Petersen himself. Undoubtedly the most important of these changes is that of the increase of the diameter of the eye, because it finds its physiological explanation in the circumstance that the eel matures in the depths of the sea. That, as a matter of fact, eels dredged from the bottom of the sea have larger eyes than one ever finds in fresh-water eels, I have proved by many comparative measurements, made between eels dredged from the sea-bottom and others which had not yet passed into the deep waters of the sea. Thus, for instance, in a male eel taken from the Messina currents, and having a total length of 34½ cm., the eye had a diameter, both vertical and transversal, of 9 mm.; and in another eel of 33½ cm. the same measurement was recorded. In a female eel, derived from the same source and purchased in the market, whose length was 48½ cm., the vertical diameter of the eye was 10 mm., and the transversal diameter rather more than 10 mm. These are not the greatest dimensions which I observed, and I conclude from these facts that the bridal-habit described by Petersen was not quite completed in his specimens, and that it becomes so only in the sea and at a great depth. In relation to these observations of mine stands the fact that the genital organs in the eel taken in the Messina currents are sometimes more developed than in eels which have not yet entered the deep water. Thus it has happened that male individuals have occurred, showing in the testes here and there knots of spermatozoa. These spermatozoa are similar to those of the *Conger vulgaris,* and must be considered as ripe. As is well known, so advanced a stage of sexual maturity has never before been observed in the common eel. This appears to be due to the fact that the males hitherto examined had not yet migrated into the deep water of the sea. . . . .

---

* *Proceedings Roy. Soc.*, vol. lx. No. 363. See also *Quart. Journ. Micr. Sci.*, New Series, vol. xxxix. part 3.

"To sum up, *Anguilla vulgaris,* the common eel, matures in the depths of the sea, where it acquires larger eyes than are ever observed in individuals which have not yet migrated to deep water, with the exception of the eels of the Roman cloacæ. The abysses of the sea are the spawning places of the common eel: its eggs float in the sea water. In developing from the egg, it undergoes a metamorphosis, that is to say, passes through a larval form denominated *Leptocephalus brevirostris.* What length of time this development requires is very difficult to establish. So far we have only the following data:—First, *Anguilla vulgaris* migrates to the sea from the month of October to the month of January; second, the currents, such as those of Messina, throw up from the abysses of the sea specimens which, from the commencement of November to the end of July, are observed to be more advanced in development than at other times, but not yet arrived at total maturity; third, eggs, which according to every probability belong to the common eel, are found in the sea from the month of August to that of January inclusive; fourth, the *Leptocephalus brevirostris* abounds from February to September. As to the other months, we are in some uncertainty, because during them our only natural fisherman, the *Orthagoriscus mola,* appears very rarely; fifth, I am inclined to believe that the elvers ascending our rivers are already one year old, and I have observed that in an aquarium specimens of *L. brevirostris* can transform themselves into young elvers in one month's time."

Report of the Heligoland Biological Station.

Wissenschaftliche Meeresuntersuchungen herausgegeben von der Kommission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel und der Biologischen Anstalt auf Helgoland. Neue Folge, Zweiter Band. Heft 1, Abt. 1. 1896.

THE EGGS AND LARVÆ OF FISHES.—In the present communication, which is to be followed by others on the same subject, the author deals with the eggs and various larval stages of the flat-fishes found in the neighbourhood of Heligoland, and with the eggs and larvæ of the sprat. Excellent figures are given of stages in the larval development of the plaice, dab, flounder, turbot, brill, scald-back, sole, solenette, and of the sprat. Similar larvæ of most of these species have already been figured by naturalists, but many intermediate stages are now shown for the first time, and it will be a great convenience to other workers to have such excellent figures of successive larvæ thus brought together.

The most important additions to our knowledge of the development of fishes which Dr. Ehrenbaum makes are the full accounts which he furnishes of the eggs and various larval stages of the scald-back (*Arnoglossus laterna*) and the solenette (*Solea lutea*), concerning which little was previously known. He has been able to show that in the case of the former species (*Arnoglossus laterna*) metamorphosis takes place in a similar way to that described by Steenstrup, Agassiz, and Pfeffer in the genus *Plagusia;* that is to say, the right eye, during metamorphosis, does not pass round the top of the head, as in the turbot, brill, etc., but appears to come through it. What really happens, however, in these cases is not that the eye actually comes through the skull of the fish, but that the dorsal fin extends forwards to the snout, whilst the eyes are still on each side, and with the rotation of the head during metamorphosis the eye is carried round and pierces the fleshy portion of the base of this fin.

Microscopic Marine Organisms in the Service of Hydrography.*

By

Professor P. T. Cleve,

University of Upsala.

It has for a long time been known that the sea abounds in microscopic organisms, both animal and vegetable. Among the former are entomostraca, infusoria, radiolarians, foraminifera, as well as larvæ of mollusca, radiates, and bryozoa. Among the plant-life the mass consists of diatoms, cilioflagellates, flagellates, and certain unicellular chlorophyllaceous algæ. For these pelagic forms Prof. Hensen has proposed the name *plankton*, which has been universally accepted.

Some years ago I examined the samples of vegetable plankton collected by the Swedish Arctic expeditions, as well as samples from various parts of the tropical seas, and I became convinced that certain parts of the oceans are characterised by different species. In the year 1893 I spent the summer at the west coast of Sweden, where I had the opportunity of examining the plankton at the marine biological station of Christineberg; that is to say, in a fjord (loch) called Gullmarsfjord. I found that in the month of June the plankton consisted mainly of cilioflagellates, *Ceratium tripos* being the most common. During the last days of the month, however, the plankton changed. The water was from that time very rich in entomostraca, and the cilioflagellates became less abundant. At the same time the mackerel appeared in the fjord. All my samples had been collected at the mouth of the fjord, where the water is not very deep. In the interior the fjord becomes deeper, as is the case also with the Scotch lochs, and I now wished to know the character of the plankton at different depths. What I hitherto had examined was the plankton of the current, called by the Swedish hydrographers the Baltic current, which in the spring and summer runs along the Scandinavian coast up to Bergen, in Norway. Below that surface current there exists, according to the Swedish hydrographers, water with lower temperature and greater salinity. In company with Prof. G. Théel, and with the aid of his net, which could be closed and opened below the water, I made in July an attempt to get plankton from different depths of the fjord. We found in the cold bottom-water very little plankton, some few specimens of a large *Sagitta* and of *Calanus finmarchicus* only. At about 30–40 metres the cilioflagellates (among them *Ceratium divergens*) were abundant, and on the surface the entomostraca. This examination was repeated during the first days of August, when I and Dr. Aurivillius had the opportunity of accompanying Prof. Pettersson and Mr. G. Ekman on the hydrographical expedition which went out at the time. The result was the same as before; but from the determination of the temperature and the salinity of the water, it became clear that the plankton had been collected in water differing in those respects, and consequently that the different strata of water were characterised by different amounts of plankton, and by different species. Samples of plankton were afterwards collected by the Swedish hydrographical expeditions at the same time as samples of water for physical and chemical research. The examination of the plankton was carried out by Dr. Aurivillius, who took charge of the animal plankton, and by myself, who undertook the vegetable.

---

* Reprinted from *Nature*, vol. lv. No. 1413.

Having examined a large number of samples, I have lately found that the plankton of the Skagerack and Kattegat can be classed according to the prevailing species, and in this way I distinguished four types, namely: (1) *Tripos-plankton,* (2) *Didymus-plankton,* (3) *Tricho-plankton,* and (4) *Sira-plankton.*

(1) The *Tripos-plankton* is characterised by its scarcity in diatoms, and its abundance in cilioflagellates and entomostraca, which give to the spirit, in which the samples are preserved, an orange or yellow colour, all the other kinds of plankton colouring it more or less deep green. Among the entomostraca, according to the publications of Dr. Aurivillius, *Paracalanus parvus, Pseudocalanus elongatus,* and *Evadne spinifera* are the most abundant. Among the cilioflagellates *Ceratium tripos,* with the variety *macroceros,* is the most common. *C. divergens, C. furca,* and *C. fusus* occur in less numbers. Diatoms are, as I have said, scarce, the most abundant being *Coscinodiscus concinnus* and *Rhizosolenia gracillima.* In winter and early spring the unicellular alga, *Halosphaera viridis,* is found in abundance. This kind of plankton characterises the water of the Baltic current, and prevails in the summer in the Kattegat and Skagerack. The organisms consist chiefly of euryheline and eurythismic species, which can withstand the dilution of the salter North Sea water by the slightly saline Baltic water.

It seems very probable that this first type of plankton may by future researches be split up into different kinds. We may thus, perhaps, distinguish one kind, characterised by *Halosphaera viridis*, and occurring in the winter; another by *Rhizosolenia gracillima*, occurring in the summer; one with *Paracalanus parvus*, and another with *Pseudocalanus elongatus*, and so on.

In all cases it seems to be certain that the water containing this first type is derived from the North Sea as well as from the Baltic.

(2) The *Didymus-plankton* consists principally of diatoms, among which the most characteristic species are *Chaetoceros curvicetus*, *Ch. didymus*, *Ditylum Brightwellii*, *Rhizosolenia alata*, and *gracillima* (the latter probably a residuum of Type 1), *Skeletonema costatum* and *Thalassiothrix Frauenfeldii* (the latter probably common to Type 3). A silicoflagellate, *Dictyocha speculum*, occurs constantly, but not abundantly. The cilioflagellates, as well as the entomostraca, are scarce.

This kind of plankton was predominant in the Skagerack and Kattegat in November, 1893, filling the fjords from the bottom to the surface. With the water containing this kind of plankton the herring arrived on the shores of Scandinavia. It seems to have been a very large bulk of water that at this time set in to the coast, as it drove away the whole of the summer water from bottom to surface.

The diatoms of this type are not known from the Arctic Ocean or from the Northern Atlantic, but are well known from the coasts of France and Belgium and the English Channel. It seems thus to be beyond doubt that the water came from the southern North Sea, along the western coast of Denmark. The temperature, as well as the salinity, were found to be variable, but the plankton constant. In the Gullmarsfjord the water at the surface had a temperature of 7° C., at a depth of 30 m. nearly 12°, and at the bottom only 4° to 5°. The salinity amounted respectively to about 26–27, 32 and 33 to 37 per thousand. This variation may be explained by the mixture of the water of the second type with the water previously present in the Kattegat. Probably the warmest water was the most pure water of Type 2, and corresponds to one of the kinds of water called by the Swedish hydrographers the *bank-water*.

(3) The third type of plankton, the *Tricho-plankton*, is distinguished by its diatoms, especially the following species: *Thalassiosira longissima*, *Rhizosolenia styliformis*, *Chaetoceros atlanticus* (in a less degree also by *Ch. borealis* and its variety *Brightwellii*), and *Biddulphia mobilensis*. The first-named species occur abundantly and almost pure in the Northern Atlantic, south of Iceland; the last-named I observed at Plymouth, West Scotland, and in the North Sea. This plankton may thus be considered a Northern Atlantic plankton. At the Scandinavian coast it seems to occur very rarely in a pure state; in fact, I have seen

it only once, in February of this year, gathered at the bottom of the Christiania fjord (100 m.), where the temperature amounted to 7·5° C., and the salinity to 34–76 per thousand, the highest figures obtained by the hydrographical examinations of all the samples gathered in February, 1896.

On the other hand, this plankton was frequently found mixed with the next type in samples collected at the time named.

(4) The fourth type, the *Sira-plankton*, consists also mainly of diatoms, but of different species, the most characteristic being *Thalassiosira Nordenskiöldii* and *Th. gravida, Chaetoceros graenlandicus, Ch. socialis, Ch. scolopendra, Ch. teres, Nitschia seriata,* many of which belong to the Arctic seas, and some of which are new to science. Among the cilioflagellates the most abundant is a variety *arctica* of *Ceratium tripos*, distinguished by Dr. Aurivillius as a constituent of the plankton of Baffin's Bay.

There can be no doubt about the Arctic origin of this type. It occurred in the Skagerack and Kattegat this year in February and March, always more or less mixed with (3) and (1). In the Skagerack the water with Types (3) and (4) was covered by a shallow layer of water with Type (1); but in the Kattegat it reached the surface. The admixture of Type (3) shows that the water on or before its arrival at the coast of Sweden was mixed with Atlantic water. The temperature and the salinity were found to vary greatly, owing to the admixture of the slightly saline Baltic water, at this time of the year very cold.

I have observed the same type of water in some slides collected on the west coast of Scotland by Mr. George Murray, and sent to me by Mr. Grove. These samples had been gathered in the spring of 1888—a year remarkable in England as an unusually cold one.

As far as the plankton researches are advanced at present we may conclude that the surface-water around the Swedish coast consists in the summer of water from the North Sea mixed with Baltic water; that in the autumn its place is taken by water from the southern part of the North Sea; and in the winter by water from the Northern Atlantic and the Arctic Ocean. Whether these changes occur regularly every year, or in certain years only, cannot be answered for the moment. Probably the last change is in correspondence, as Professor Petersen has recently suggested, with variations in the amount of water which the Gulf Stream carries past Iceland, westwards to Davis Strait, and eastwards to the Arctic Ocean.

I think I have proved by the above that the examination of plankton is a matter of the greatest interest, not only in relation to hydrography, but also to meteorology and to fishery questions. There can be no doubt about the close connection between the state of the sea and the movements of the air, and the still obscure causes of the migration of fishes may be found to be intimately connected with the change of water containing different kinds of plankton.

It is thus an important matter that the plankton of the North Sea should be thoroughly and systematically examined; but for this, international co-operation of all the nations around the North Sea is required. I imagine that a central station, under the direction of competent persons and provided with adequate accommodation, might be erected. Samples could be collected at certain intervals, and by the same kind of apparatus at different stations, and sent to the central one for examination. The details should be published every month, and the general results formulated in a way that would be useful to hydrographers, meteorologists, etc. The marine biological stations already in existence will probably be found willing for co-operation in such an undertaking; but they will be able to collect plankton only near the shores, or at short distances from them. For getting samples from the open seas, the officers of the steamers crossing the North Sea and the Northern Atlantic might be found willing to assist, as the plankton may, as Dr. John Murray hinted to me, be procured by pumping water into a silk net. I recently tried this method whilst crossing from Edinburgh to Göttenburg. I fastened the net to the pump when the deck was being washed, and in this way I obtained sufficient plankton to prove that in the last days of July the North Sea was almost free from diatoms, and its plankton consisted mainly of cilioflagellates and entomostraca.

The Regulations of the Local Sea Fisheries Committees in England and Wales.

By

E. J. Allen, B.Sc., Director of the Plymouth Laboratory.

The powers conferred on the Board of Trade, under the Sea Fisheries Regulation Act of 1888, to create, upon the application of a County or Borough Council, a local Fisheries District, and to provide for the constitution of a Local Fisheries Committee for the regulation of the sea fisheries carried on within the district, have been requisitioned by the majority of the Councils of the maritime counties of England and Wales, and at the present time Fisheries Districts and Fisheries Committees are constituted around nearly the whole coast line, the Committees having jurisdiction over all fishing carried on within the three-mile limit. The only portion of coast still unprovided for is that which lies in the counties of Norfolk and Suffolk, between Happisburg and Dovercourt.

The following is a list of the Fisheries Districts, with their boundaries, as they now exist:—

Northumberland—from the boundary between England and Scotland to the river Tyne.

North-eastern—from the river Tyne to Donna Nook Beacon, on the coast of Lincolnshire.

Eastern—from Donna Nook Beacon to Happisburg, on the coast of Norfolk.

Between Happisburg in Norfolk and Dovercourt in Essex no Fisheries District has been established.

Kent and Essex—from Dovercourt in Essex to Dungeness.

Sussex—from Dungeness to Hayling Island.

Southern—from Hayling Island to the western boundary of Dorset.

DEVON—*Southern section*, from eastern boundary of Devon to Rame Head in Cornwall. *Northern section*, from eastern to western boundary of Devon.

CORNWALL—from northern boundary of Cornwall to Rame Head.

GLAMORGAN—from Nash Point to Worms Head.

MILFORD HAVEN—from Worms Head to Cemmaes Head in Pembroke.

WESTERN—from Cemmaes Head to the boundary between Carnarvon and Denbigh.

LANCASHIRE—from the boundary between Carnarvon and Denbigh to Haverigg Point in Lancashire.

CUMBERLAND—from Haverigg Point to Sark Foot.

The powers of the Local Fisheries Committees, as extended by subsequent Acts (Fisheries Act, 1891, and Sea Fisheries [Shell Fish] Regulation Act, 1894), include the making of bye-laws, subject to the approval of the Board of Trade, for the prohibition or regulation of any method of fishing for sea fish, for the establishment of close seasons for any sea fish, and for the regulation, protection, and development of fisheries for all kinds of shell fish (molluscs and crustaceans). Those powers have been largely exercised by the Committees, and the full text of all the bye-laws, which have received the sanction of the Board of Trade, is published in the *Annual Reports of the Inspectors of Sea Fisheries for England and Wales.*

It may be useful to those interested in the protection of fisheries, more especially of inshore fisheries, to bring together under subject headings the regulations now in force, which vary considerably in the different districts around the coast. The regulations and restrictions apply to the sea within three miles of the coast, but not to those tidal estuaries which are under the jurisdiction of Boards of Salmon Conservators.

Trawling with Steam Vessels.

Trawling from vessels propelled otherwise than by sails or oars is entirely prohibited on the east coast of England, from Northumberland to the southern limit of the Eastern Fisheries District at Happisburg, on the coast of Norfolk. South of this point steam trawling is permitted along the east coast, and along the south coast of Sussex as far westward as Hayling Island, the mesh of the trawl, however, being regulated, as for sailing trawlers (*see below*), within the limits of the Kent and Essex and the Sussex Sea Fisheries Districts.

Along the remainder of the south coast (Southern, Devon, and Cornwall Districts), and along the west coast of England and Wales, steam trawling is forbidden, excepting in the Milford Haven and Cumberland Districts.

Trawling with Sailing Vessels.

I. Trawling for Sea Fish.

NORTHUMBERLAND DISTRICT.—Trawling is prohibited.

NORTH-EASTERN DISTRICT (*Durham and Yorkshire*).—Prohibited, excepting in Bridlington Bay, between February 1st and September 1st; beam not to exceed 22 ft., and net to be raised and cleared at least every half-hour.

EASTERN DISTRICT (*Lincolnshire and north coast of Norfolk*).—In northern portion of district,* the length of trawl beam must not exceed 22 ft., and the net must be raised and cleared not less than once in every hour.

In southern portion of district † trawling is prohibited.

Norfolk (*east coast*) *and Suffolk.*—No district, and therefore no restrictions.

KENT AND ESSEX DISTRICT.—No trawl net may be used having more than 36 rows of knots to the linear yard.

SUSSEX DISTRICT.—No trawl net may be used having more than 30 rows of knots to the yard.

SOUTHERN DISTRICT (*Hants and Dorset*).—No restrictions.

DEVON DISTRICT.—Trawling is prohibited in the bays on the south coast. On the north coast there are no restrictions.

CORNWALL DISTRICT.—No restrictions.

GLAMORGAN DISTRICT (*south coast of Wales*).
Mesh—not less than 1½ inch gauge.‡
Circumference of net—not less than 100 meshes.
Beam—not greater than 40 feet.

MILFORD HAVEN DISTRICT.—No restrictions.

WESTERN DISTRICT (*west coast of Wales*).
Mesh—not less than 1½ inch gauge.
Circumference of net—not less than 100 meshes.
Beam—not greater than 45 feet.

---

* "That portion of the said district which lies to the westward of a line drawn true north-east from the lightship known as the 'Lynn Well Light,' and to the northward of a straight line drawn from Gibraltar Point to Gore Point."

† "That portion of the said district which lies between a line drawn true north-north-east from the building standing upon Salthouse Beach, known as Randall's Folly (or the Sailor's Refuge), and a line drawn true north-east from Cromer Lighthouse."

‡ "No person shall use any trawl net for taking sea fish, other than shrimps or prawns, having a mesh through which a square gauge of 1½ inches measured across each side of the square, or 6 inches measured round the four sides, will not pass without pressure when the net is wet."

LANCASHIRE DISTRICT.

Mesh—not less than 1¾ inch gauge.

[Except south of Formby Point, from July 1st to October 15th, mesh not less than 1½ inch gauge may be used.]

Circumference of net—

With beam greater than 25 ft., circumference not less than 80 meshes.
„ „ „ 18 ft. „ „ „ 60 „
„ less „ 18 ft. „ „ „ 50 „

Beam—

From January 1st to June 30th not to be greater than 30 feet.

Vessel—

From January 1st to June 30th not to be greater than 15 tons.

CUMBERLAND DISTRICT.—No restrictions.

II. **Shrimps and Prawns.**

(*All regulations applying to fishing for shrimps and prawns, whether by trawling or other means, will be included under this heading.*)

NORTHUMBERLAND DISTRICT.—Trawling prohibited.

NORTH-EASTERN DISTRICT (*Durham and Yorkshire to Donna Nook*).—Beam not to exceed 8 feet in extreme length, and net to be raised and cleared at least once in every half-hour.

Excepting:—(1) Between a straight line drawn true east from Castle Eden Dene, and a straight line drawn true north-east from Skinningrove Beck, a push net only may be used.

(2) In the River Humber, between a straight line drawn from the entrance to St. Andrew's Dock to the northern extremity of the pier at New Holland, and a straight line drawn from Spurn Head Lighthouse to Donna Nook Beacon, between March 1st and October 31st, a trawl having a beam not exceeding 20 feet may be used, the net to be raised and cleared not less than once in every hour.

EASTERN DISTRICT (*Lincolnshire and north coast of Norfolk*).—Length of trawl beam not to exceed 20 feet, and net not to have any pocket. Between December 1st and the last day of February no trawl net may be used for taking shrimps or prawns.

East coast of Norfolk and Suffolk.—No district, and therefore no restrictions.

KENT AND ESSEX DISTRICT.—No trawl net may be used having more than 108 rows of knots to the linear yard, except that for a length of 8 feet from the cod end there may be not more than 144 rows of knots to the yard.

SUSSEX DISTRICT.—No restrictions.

SOUTHERN DISTRICT (*Hants and Dorset*).—No restrictions.

Devon District.—Trawling in the bays on the south coast is prohibited, with the exception of trawling for shrimps or prawns in Plymouth Sound, with a beam not exceeding 8 feet in length, the net to be raised and cleared at least once every half-hour.

Cornwall District.—No restrictions.

Glamorgan District (*south coast of Wales*).
Mesh—not less than $\frac{3}{8}$ inch gauge.*
Circumference of net—not less than 160 meshes.
Beam—not greater than 40 feet.

Milford Haven District.—No restrictions.

Western District (*west coast of Wales*).
Mesh—not less than $\frac{3}{8}$ inch gauge.
Circumference of net—not less than 160 meshes.
Beam—not greater than 45 feet.

Lancashire District.
Mesh—not less than $\frac{3}{8}$ inch gauge.
Circumference of net—
With beam greater than 20 ft., not less than 140 meshes.
„ „ less „ 20 ft. „ „ 120 „
Beam—not greater than 25 feet.

Cumberland District.—No restrictions.

Seining.

In the North-eastern (*Yorkshire and Lincolnshire*), Western (*west coast of Wales*), and Lancashire Districts seining is prohibited, excepting for the capture of sand-eels for bait in the North-eastern, and for herring, mackerel, and sparling in the Western and Lancashire Districts. In these cases also the net is regulated.

In the Kent and Essex, Sussex, and Glamorgan Districts there are general mesh regulations for all nets used in the capture of sea fish, which would include seines.

In other districts there are no regulations.

The following regulations in the above-named districts may be mentioned:—

North-eastern District.—A net may be used for taking sand-eels for bait, without a pocket; net 108 feet long and 12 feet deep, the central portion (12 ft. × 12 ft.) to be of closely-textured netting.

---

* "No person shall use any net for taking shrimps or prawns having a mesh through which a square gauge of three-eighths of an inch measured across each side of the square, or $1\frac{1}{2}$ inches measured round the four sides, will not pass without pressure when the net is wet."

KENT AND ESSEX DISTRICT.—No net may be used for sea fish having more than 144 rows of knots to the yard.

SUSSEX DISTRICT.—No seine or draft net may be used having more than 30 rows of knots to the yard, excepting when fishing for herring or mackerel, at any time, or for sprats during November, December, and January.

GLAMORGAN DISTRICT.—No net for sea fish (except sprats) may have a mesh less than 1 inch gauge.

WESTERN DISTRICT (*west coast of Wales*).—No net for taking mackerel or herring may have mesh less than 1 inch gauge.

LANCASHIRE DISTRICT.—Similar to Western District.

Trammel, Stake, and Stop Nets.

On the east coast the only bye-law relating to such nets is one made by the North-eastern Committee, whereby the use of trammel nets is prohibited in certain specified districts off the mouths of the principal rivers. On other parts of this coast the use of these nets is unrestricted.*

On the south coast the only regulation applies to Chichester Harbour, where no stop nets may be set across the creeks within one hour before and after low water.

On the west coast regulations exist in the Glamorgan, Western, and Lancashire Districts only, as follows:—

GLAMORGAN DISTRICT (*south coast of Wales*).—Stop nets for sprats must have a mesh not less than $\frac{9}{16}$ inch gauge. All stake and stop nets must be marked by buoys or poles, must be at least 10 yards from other stake nets or any fishing weir, and a pool 12 inches deep at low water must be kept for each net from May to October, at other times 6 inches deep, such pool to be three-quarters the size of the cage of the net, and not less than 36 square feet in area.

WESTERN DISTRICT (*west coast of Wales*).—Trammel nets are prohibited. The position of stake nets must be marked by poles or buoys: the nets must not be nearer the centre of any stream than the edge of the stream at low water, and they must not be nearer than 50 yards to any other stake net.

---

* In this connection particular notice should be taken of the fact that we are not considering any bye-laws applicable to estuaries under the jurisdiction of Boards of Salmon Conservators.

Lancashire District.—Trammel nets are prohibited. The regulations for stake nets are generally similar to those in force in the Western District, but the distance from other stake nets must be 150 yards. There is also a somewhat curious bye-law, which reads as follows:—" No person shall use, in fishing for mackerel or herring, any stake net except at the times and places at which, and in the manner in which, such nets have been heretofore commonly used for the capture of such fish respectively."

Smelt or Sparling.

In the Northumberland District there are no restrictions. In the North-eastern sparling nets may be used only between July 21st and March 21st, and mesh of net must not be less than six-tenths of an inch from knot to knot.*

In the Eastern District the nets must have not more than 24 knots to the foot, and they may not be used between April 1st and August 31st.

In the Kent and Essex District the net must have not more than 72 rows of knots to the yard, and must not be more than 60 fathoms long.

On the south coasts of England and Wales there are no restrictions.

In the Western District (*west coast of Wales*) the mesh of the net must allow a square gauge with each side ¾ inch long to pass through, whilst in Lancashire the fish may only be taken with seine or draft net, the size of mesh is increased to one inch, and the fish may not be caught between April 1st and October 31st.

Crabs and Lobsters.

In considering the regulations relating to crabs and lobsters, it must be borne in mind that the Fisheries (Oyster, Crab, and Lobster) Act, 1877, applies to the whole country, and makes it illegal to take, have in possession, sell or expose for sale, any edible crab which measures less than 4¼ inches across the broadest part of the back (except when for use as bait); or any edible crab carrying spawn attached to the tail; or any edible crab which has recently cast its shell; or any lobster which measures less than eight inches from the tip of the beak to the end of the tail, when spread out flat.

The Sea Fisheries Committees have made the following additional regulations in their respective districts:—

Northumberland District.—No additional restrictions.

---

* There is also a restriction as to the nature of the material of which the net is made.

NORTH-EASTERN DISTRICT (*Durham and Yorkshire*).—Crabs under 4¼ inches not to be taken, even for bait. Lobsters under 9 inches long not to be taken. No lobsters or crabs to be taken between September 1st and January 31st of following year.

EASTERN DISTRICT (*Lincolnshire and north coast of Norfolk*).—Crabs under 4¼ inches not to be taken, even for bait.

No lobster carrying spawn, and no lobster which has recently cast its shell and is still soft, to be taken. From November 1st to June 30th no crabs known locally as "whitefooted" to be taken.

KENT AND ESSEX DISTRICT.—No lobster carrying spawn to be taken.

SUSSEX, SOUTHERN (*Hants and Dorset*), AND DEVON DISTRICTS.—No restrictions.

CORNWALL DISTRICT.—No male edible crab less than 6 inches broad,
„ female „ „ 5 „
may be taken.

GLAMORGAN AND MILFORD DISTRICTS.—No restrictions.

WESTERN DISTRICT (*west coast of Wales*) .	No lobsters or crabs carrying spawn may be taken.
LANCASHIRE DISTRICT	

No lobster less than 9 inches from beak to tail; no edible crab less than 5 inches across broadest part of back, may be taken.

CUMBERLAND DISTRICT.—No restrictions.

Molluscs.

Oysters.—In addition to the close times fixed by Act of Parliament, viz., for deep-sea oysters from 15th June to 4th August, and for all other oysters from 14th May to 4th August, the following are the regulations made by Local Fisheries Committees for their respective districts:—

KENT AND ESSEX DISTRICT.—No cultch may be removed from an oyster ground.

SOUTHERN DISTRICT (*Hants and Dorset*).—No oysters may be taken from 15th May to 30th September, and none may be taken at any time which will pass through a circular ring of 2 inches in internal diameter, except for stocking and breeding purposes.

No cultch or other material for the reception of spat may be removed.

WESTERN DISTRICT (*west coast of Wales*) .	No oysters may be taken which will pass through a circular ring 2½ inches in internal diameter.
LANCASHIRE DISTRICT	

In other districts no additional restrictions have been made.

Mussels. — EASTERN DISTRICT (*Lincolnshire and north coast of Norfolk*). — No mussels may be taken from May 1st to August 31st, nor any less than 2 inches in length at other times, except for stocking or breeding.

No instrument may be used for taking mussels other than a rake not exceeding 18 inches broad, and with the teeth 1 inch apart.

GLAMORGAN DISTRICT (*south coast of Wales*).—No mussels may be taken in May, June, or July, except for stocking or breeding purposes.

Mussels may be taken only (*a*) with a dredge, (*b*) by hand, or (*c*) with a rake not more than 3 feet wide, with the teeth 1 inch apart.

WESTERN DISTRICT (*west coast of Wales*).—No mussels may be taken in May, June, July, or August, excepting for stocking, breeding, or bait (in one part of the district the prohibition extends also to April, September, and October), and none may be taken at any time less than 2¼ inches long.

Mussels may be taken only (*a*) by hand, (*b*) with a rake not exceeding 3 feet wide, used from a boat, and when the bed is covered with at least 4 feet of water.

LANCASHIRE DISTRICT.—No mussels may be taken in May, June, July, or August, and none at any time less than 2¼ inches long.

Mussels may be taken only (*a*) by hand, (*b*) with a rake not exceeding 3 feet wide, used only from a boat, and when the bed is covered with at least 4 feet of water.

In other districts no restrictions have been made.

Cockles.—Regulations are in force as follows:—

EASTERN DISTRICT (*Lincoln and north coast of Norfolk*).—No instrument may be used for taking cockles except a rake not more than 12 inches long, with teeth ¾ inch apart.

GLAMORGAN DISTRICT (*south coast of Wales*).—Cockles may only be taken by hand, or with a rake not more than 12 inches wide, with teeth ¾ inch apart.

WESTERN DISTRICT (*west coast of Wales*).—Cockles may only be taken by hand, or with a rake not more than 12 inches wide, with teeth ¾ inch apart. None may be taken which pass through an oblong gauge ¾ inch wide and 2 inches long.

LANCASHIRE DISTRICT.—No cockles may be taken which pass through an oblong gauge ¾ inch broad and 2 inches long. They may be taken only (*a*) by hand, (*b*) with a craam having not more than three teeth, (*c*) with other instruments under regulations which differ in different parts of the district.*

Periwinkles.—In the Sussex District periwinkles may not be taken between April 1st and October 31st, and in the Southern District not between May 1st and August 31st. In other districts no regulations exist.

Injurious Substances.

Bye-laws prohibiting the deposit or discharge of any solid or liquid substance detrimental to sea fish or sea fishing are in force in the following districts: Kent and Essex, Sussex, Southern, Devon, and Lancashire.

---

* Bye-law 20. No person shall fish for cockles except—

(*a*) By hand, or

(*b*) With an instrument locally known as a craam, having not more than three teeth: provided that—

(1) Between the 1st day of November and the last day of February following, both inclusive, it shall be lawful to use an instrument locally known as the jumbo, not exceeding 4 feet 6 inches in length, 14 inches in width, and 1 inch in thickness, provided that such instrument shall be constructed entirely of wood, and shall not be dragged across the cockle beds or artificially weighted.

(2) In that part of the district which lies to the southward of a line drawn true west from the mark known as "Rossall Landmark," near Fleetwood, it shall be lawful to use a rake not exceeding 12 inches in width.

(3) In that part of the district which lies between a straight line drawn seawards through the north-west sea marks near Formby Point, and a line drawn true west from the western extremity of the southern training wall in the river Ribble or Gut Channel, it shall be lawful to use a spade.

Contributions to Marine Bionomics.

By

Walter Garstang, M.A.,

Fellow and Lecturer of Lincoln College, Oxford.

II. The Function of Antero-lateral Denticulations of the Carapace in Sand-burrowing Crabs.

The antero-lateral margins of the carapace in many of the crabs of our own and of foreign coasts are beset with a row of teeth or spines, which vary in character and number in different species and genera. In the Oxyrhyncha (Spider-crabs) the whole surface of the carapace is generally studded with spines and stiff hairs of a peculiar character, but there is no general restriction of these processes of the carapace to the antero-lateral margins of the body. These crabs, moreover, do not adopt burrowing habits. Their armature of spines, tubercles, and hairs is employed, as is well known, for protective purposes: in some cases possibly as an actual defence against attack, in others (*i.e.*, *Eurynome aspera*) as a means of protective resemblance to their surroundings; but in the great majority as mere pegs and hooks for the fixation of foreign bodies, such as algæ, hydroids, polyzoa, and ascidians, for purposes of concealment and disguise.

In the Catometopa (Land-crabs, etc.) the carapace is usually smooth over its whole surface. These animals often burrow in sand, but for the most part their burrows are permanent subterranean tunnels and chambers.

In the Cyclometopa, however—the group which includes most of our commoner British crabs—the back of the carapace is generally smooth, while the antero-lateral margins are in most forms conspicuously serrated. Most of these animals inhabit sandy or gravelly areas, and show a marked propensity towards burrowing habits. Their burrows are never* permanent channels or tunnels in the sand, but are mere temporary excavations, the sand, mud, or gravel being in actual contact with their bodies when imbedded.

So far as I am aware no one has hitherto elucidated the remarkable constancy of antero-lateral serrations of the carapace in this group of crabs. I here present evidence which tends to show that the presence of conspicuous serrations on these margins of the carapace is functionally related to the exigencies of respiration when these animals are buried in sand.

---

* *Scylla serrata* of the Natal coast *appears* to be exceptional in this respect. (Krauss, *Die Südafricanischen Crustaceen*, 1843, p. 12.)

The marginal teeth are perhaps best developed and most conspicuous in crabs of the family Portunidæ (Swimming-crabs). As M. Alphonse Milne-Edwards has remarked: "Je ne connais aucun Portunien où le bord latéro-antérieur de la carapace soit entier ou armé d'épines arrondies ou de tubercules obtus." (1860, p. 202.)

In *Bathynectes longipes* there are five sharp-pointed teeth on each of the antero-lateral borders. These teeth increase in size regularly from before backwards, and the posterior tooth is a particularly stout and sharp structure. This crab is almost invariably an inhabitant of sandy areas (*e.g.*, Mounts Bay in Cornwall); and the individual whose habits I am about to describe was also dredged upon a bottom of fine sand in the neighbourhood of the Eddystone.

In an aquarium containing sand the crab burrows into the sand just beneath the surface, leaving its eyes and the transverse slit-like aperture of the buccal frame exposed. The crab is actually imbedded up to the anterior edge of the external maxillipeds; but it pushes away the sand in front of it by means of these appendages, and when at rest maintains these appendages in a sloping posture, so that they act as a quadrangular sieve-like fence in front of the buccal area. This happens both in very fine siliceous sand and in fine shell sand. The crab was not seen at any time to go completely beneath the surface, though I do not mean to imply by this that the crab never buries itself entirely. This may or may not be the case. *Atelecyclus heterodon* is another sand-burrowing crab, whose habits I have studied for a much longer period; and this crab has very diversified habits. It may remain partially imbedded at the surface of the sand, with its eyes and a broad funnel formed by the second antennæ alone protruding, or it may disappear completely beneath the sand to a depth of several inches.

When the crab (*Bathynectes longipes*) is partially imbedded in the sand as above described, it may be noticed that the chelipeds are flexed and approximated to the under side of the antero-lateral regions of the carapace in an attitude precisely similar to that assumed by *Atelecyclus heterodon*, or the Oxystome crab *Matuta*, under the same conditions (1897). The position of the cheliped is such that the marginal teeth of the antero-lateral region of the carapace exactly overhang the slit-like orifice between the distal half of the cheliped (carpopodite and propodite) and the pterygostomial fold of the carapace. There is thus produced on each side of the crab, between cheliped and carapace, a channel similar to that which would be produced by the approximation in parallel planes of two flat plates. This channel communicates below with the afferent (inhalant) aperture of the branchial chamber, which is situated at the base of the cheliped, and opens above through the notches between the teeth of the antero-lateral margins of the carapace. Since the back of the crab is covered with sand, it will readily be understood from this description that the antero-lateral teeth act as a coarse sieve or grating placed over the orifice of this accessory channel, and that they prevent the accidental intrusion of sand-particles into the lumen of the channel, a function which it was easy to determine that they efficiently discharged.

The pair of accessory channels produced by the approximation of chelipeds to carapace I propose to term the "exostegal channels," owing to their situation on the external face of the branchiostegite. I show elsewhere (1897) that these channels probably represent in a generalised condition certain remarkable accessory afferent branchial canals of the Oxystome Brachyura, which attain their most specialised form and relations in *Ebalia* and other Leucosiidæ.

M. Alphonse Milne-Edwards (1860, p. 207) states that in the Portunidæ "les mains ne sont jamais conformées de facon à pouvoir s'appliquer exactement contre la région buccale, ainsi que cela se voit chez quelques autres Brachyures nageurs tels que les Calappes et les Matutes." This contrast is quite in accordance with my view, that the afferent channel of the Portunidæ represents a primitive and relatively unspecialised type, from which the highly elaborate canals of the Oxystomata have been derived.

That these accessory channels in the Portunidæ are functionally connected with the respiratory process, was demonstrated by me in the case of *Bathynectes longipes* in the following manner:—

When the crab was partially imbedded in sand with its face close to the front of a square glass aquarium, in the attitude already described, it could be seen that beneath the body of the crab was a shallow ventral water-chamber, free from sand. The crab was resting with its body in an approximately horizontal plane. Sand-particles were supported over the orifice of the exostegal channel by the sieve-like row of teeth along the antero-lateral margins. Some water, coloured black with Indian ink, was then added by means of a pipette to the water lying above the slit between cheliped and carapace. The coloured water was at once sucked downwards between the grains of sand into the exostegal channel in waves which apparently corresponded to blows of the scaphognathite, and after a few seconds emerged in a black stream out of the afferent orifice of the branchial chamber situated in front of the mouth. It was quite clear that the water passed downwards through the exostegal channel to the afferent aperture at the base of the cheliped, and that it entered the branchial chamber by this aperture.

Similar observations and experiments were made upon numerous specimens of *Atelecyclus heterodon*, a crab belonging to an altogether different family. In this crab the antero-lateral margins are provided with as many as nine teeth, but the function of the teeth was found to be essentially similar. Owing to the different form of the body, and the different shape of the cheliped in the two crabs, the orifice of the channel between cheliped and carapace is of greater relative extent in *Atelecyclus* than in *Bathynectes;* but the length of the denticulated margin of the carapace was found to correspond precisely with the extent of the inhalant gap in each case. The following conclusions may be drawn, therefore, from these observations:—

(1) Antero-lateral denticulations of the carapace in crabs may subserve a sieve-like function.

(2) The extent of the denticulated area corresponds with the extent of the inhalant gap between the carapace and the cheliped when the latter appendage is approximated to it in the flexed position.

It is also obvious that a new function must be ascribed to the chelipeds of sand-burrowing crabs provided with antero-lateral denticulations of the carapace. In such cases the chelipeds act as organs temporarily subservient to the respiratory process by providing a broad operculum to the exostegal channel. Attention may be recalled in this connection to the fact elucidated by Milne-Edwards in 1839, that in the Leucosiidæ the floor of the afferent branchial channel is also provided by one of the appendages, in this case by the external maxillipeds. The relations of the afferent channel in the Leucosiidæ to the external channel which I have now described in the Cyclometopa are discussed by me in the paper to which reference has already been made (1897).

The subservience of the chelipeds to the respiratory process enables me, moreover, to explain the function of a remarkable spine which in the Portunidæ is almost universally present on the inner margin of the distal extremity of the carpal joint (carpopodite or wrist) of the cheliped. This carpal spine, though usually strong and conspicuous, presents various minor modifications of form which are employed by systematists in the discrimination of different species.

The appearance of the spine in *Bathynectes longipes* is represented by Bell and Risso. When the cheliped is fully extended the carpal spine projects freely from its anterior margin; but when the propodite is flexed towards the proximal part of the cheliped, it is arrested at a certain angle with the carpopodite by the carpal spine in question. If now the arm (meropodite) of the cheliped be approximated to the carapace in the position requisite for the completion of the exostegal canal, it will be found that the angle at which the propodite has been arrested by the carpal spine is precisely the angle required for the proper apposition of cheliped to carapace in connection with the respiratory process. The carpal spine acts then as a stay or barrier to excessive flexion of the cheliped. Its function corresponds, therefore, in part to the function of such skeletal processes as the olecranon of the human ulna, which prevents excessive extension of the arm. Examination of a series of Portunids reveals that the variations in the form of the carpal spine in different species and genera are all functionally correlated with the different shapes and proportions of the carapace, and of the segments of the cheliped in the forms examined; the result in all cases being that the shape of the carpal spine is adapted to ensure the due amount of flexion of the cheliped for the completion of the respiratory channel between cheliped and carapace.

A similar function seems also to be discharged by the enlarged posterior spine of the antero-lateral margins in *Bathynectes longipes*, since the carpopodite presses upwards against it during flexion of the cheliped. An examination of preserved specimens of the Mediterranean *Lupa hastata*, and of the American *Callinectes sapidus*, in which the posterior spine is greatly elongated, seems to me to support this view, though I do not regard the evidence in this case as altogether unequivocal. A complete explanation of the enlargement of this posterior antero-lateral spine should also throw light on the great epibranchial spines of the Oxystome genus *Matuta*, and of the Leucosiid genera *Iphis* and *Ixa*. In the latter cases any relation between the development of the spines and the formation of an inhalant chamber between cheliped and carapace is precluded by the known course of the afferent current in a gutter running between the pterygostomial plate and the exopodite of the third maxilliped.

The phenomena presented by the respiratory processes of these sand-burrowing crabs throw light, as it seems to me, not only on the problem of the utility of a number of morphologically trivial, but systematically important features of Decapod Crustacea, but also on an altogether different problem, viz., the phylogeny of the Brachyura Oxystomata. Crabs of the latter group are all characterised by their sand-burrowing habits of life. Similarity of habits often induces homoplastic changes of form in types genetically distinct; but there are certain significant details of structure in the different Oxystome types which appear to me to be only explicable on the view that these crabs are descended from ancestors in which the form of the body closely resembled that of sand-burrowing Cyclometopa in being provided with antero-lateral serrated margins, and in which the chelipeds were employed for the production of an extensive inhalant channel, completely roofed over by the projecting teeth of the carapace. For a fuller discussion of this subject I must refer the reader to another paper to be published in the *Quarterly Journal of Microscopical Science* (1897).

BIBLIOGRAPHY.

Bell, T.—*British Stalk-Eyed Crustacea,* 1853.

Garstang, W.—"On some Modifications of Structure subservient to Respiration in Decapod Crustacea which burrow in sand, with remarks on the Utility of Specific Characters in the genus Calappa, and the description of a new species of Albunea." *Quart. Jour. Micr. Sci.,* 1897.

Milne-Edwards, A.—"Hist. des Crust. Podophth. Fossiles." *Ann. Sci. Nat.* (4) xiv. 1860.

Milne-Edwards, H.—"Rech. sur le Méchanisme de la Respiration chez les Crustacés." *Ann. Sci. Nat.* (2) xi. 1839.

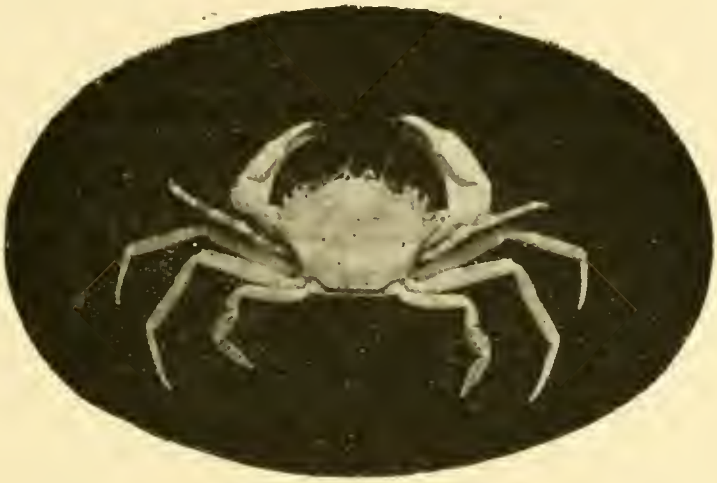


FIG. 1.

Fig. 1.—*Bathynectes longipes.* Dorsal view, showing the five teeth of the antero-lateral margins. The chelipeds are in a half-extended condition; their propodites (hands) are shown resting against the carpal spines. The specimen shows an abnormality in the union of the two anterior marginal teeth of the right side to form a single bifid tooth.

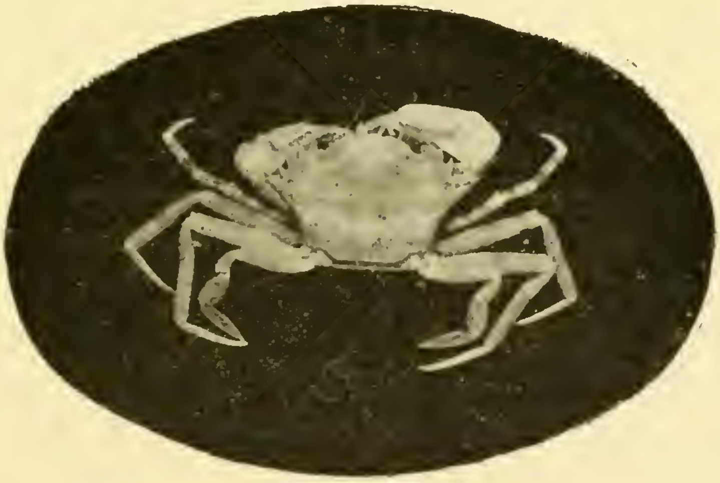


FIG. 2.

Fig. 2.—*Bathynectes longipes.* Dorsal view, showing the position of the chelipeds after flexion of the wrists (carpopodites) as well as of the hands. The left cheliped is in the attitude assumed by the crab when imbedded in sand; the antero-lateral teeth are seen to form a sieve above the orifice of the inhalant gap between cheliped and carapace. On the right side the arm (meropodite) of the cheliped does not rest in its proper position beneath the enlarged posterior marginal tooth; hence the inhalant gap is imperfectly formed, and its aperture is imperfectly covered by the marginal teeth.

III. The Systematic Features, Habits, and Respiratory Phenomena of Portumnus nasutus (Latreille).

The crab whose habits I now describe has not previously been recorded as an inhabitant of British seas. I found two specimens, both male, imbedded in a patch of coarse shell sand on the south side of Drake's Island at low water, spring tides: one on August 11th, 1896, and the other on the following day.

1. Nomenclature.

My first impression on noticing this remarkable little crab was that I had an abnormal specimen of a young *Carcinus maenas* before me; but the possibility of such a leap from the normal as the frontal area of this specimen would produce on a variation-chart was soon disposed of by Professor Weldon, and we identified the crab with the *Portunus biguttatus* of Risso (1816), now usually known under the name *Platyonichus nasutus* of Latreille (1825, p. 151; cf. also Milne-Edwards, 1834; Costa, 1853, p. 11; Carus, 1885).

The genus *Platyonichus* of Latreille (1818) was originally coextensive with the genus *Portumnus* of Leach (1815), Latreille having simply altered Leach's name owing to its similarity to the name *Portunus*, with which he feared it might be confused. Dana (1852), however, and Bell (1853), showed that the species included within the genus *Platyonichus* were separable into two well-marked groups, which were accordingly named by these writers *Platyonichus* and *Portumnus* respectively, the latter name being reapplied to the group which included Leach's type, viz., *Portumnus latipes.* It is to the latter group that *Platyonichus nasutus* belongs, so that I must refer to it for the future as *Portumnus nasutus.*

It is true that the earliest specific name applied to the present species is *biguttatus* of Risso (1816), the name *nasutus* of Latreille (1825) being nearly ten years later. Since, however, the species has been invariably referred to under Latreille's name, probably owing to the influence of Milne-Edwards' adoption of it, I submit that we have here an exceptional case which demands exceptional treatment. The rule of priority provides a decisive method of dealing with a confused and complicated synonymy; but its application in the present case could not be urged on such grounds, and would be distinctly inconvenient. I shall therefore adhere to the employment of Latreille's name *nasutus* in referring to the species under discussion. In the event, however, of possible differences being discovered between Mediterranean and Atlantic races of this species, I would point out that Risso's name was created for Mediterranean specimens, while Latreille's type came from the west coast of France.

2. Generic Characters.

The genus *Portumnus* takes its place together with *Carcinus, Platyonichus,* and *Polybius* in the Platyonichinæ, a sub-family of the Portunidæ distinguished from the Portuninæ by the absence of lateral ridges on the prælabial plate, and by the absence of a distinct accessory lobe to the endopodite of the first maxillipeds.

Portumnus is distinguished from *Platyonichus* by having the dactylus of the fifth thoracic leg of a slender lanceolate form, and the carapace not broader than long. In *Platyonichus* the dactylus is elliptical or broadly oval, and the carapace is broader than long. To these distinctions I may add that in *Platyonichus* the interorbital margin is at most tridentate or quadridentate, while in *Portumnus* the inner angle of the orbit contributes a distinct accessory tooth to the frontal margin, rendering this margin five-toothed, as in *Polybius Henslowii.*

3. Specific Characters.

The two species of the genus which alone are known to me are *P. latipes* (Pennant) and *P. nasutus.* A description of the former species may be found in Bell (1853) under the name *Portumnus variegatus.* The characteristic features of *P. nasutus* are as follows:—

Frontal area projecting in front of the orbits in the form of a conspicuous triangular lobe with gently undulate lateral margins.

The undulations mark the subdivision of the interorbital margin into five rounded lobules, which correspond to the five interorbital teeth of *P. latipes.* The interorbital lobe bends downwards in front.

The carapace is relatively broader than in *P. latipes,* so that the antero-lateral margins make a sharper angle with the median transverse axis.

The orbit shows two superior fissures and one inferior fissure (*pace* Latreille and H. Milne-Edwards, who mention only one superior fissure), while in *P. latipes* the orbit is stated to be either entire (Bell; Leach, 1815) or provided with a single fissure above (H. Milne-Edwards, 1834).

The basal joint of the second antenna is movable.

4. Colour.

The colour of the carapace of *Portumnus nasutus* is thus described by Risso (1816, p. 31)—"yellowish-white, adorned with two great spots of coral-red . . . The red spots are larger in the female than in the male." On account of the presence of these spots Risso named the species *Portunus biguttatus, portune à deux taches, portune bimaculé* (p. 25).

Costa, on the other hand (*Addizioni*, 1853, p. 11), describes the colour as "livid olive-brown tending towards purple; that of the feet and of the inferior face more pallid. In fresh specimens one may sometimes observe two rose-coloured spots in the middle of the carapace, which vanish after death."

Of my own specimens the larger one was of a uniform dull greenish yellow colour, the smaller one having the carapace and basal joints of the legs absolutely white, and the two terminal joints of the four posterior pairs of thoracic legs coloured pale brown and amethyst-violet. No reddish spots were visible in the living specimens. It is possible that these spots are only to be observed in the breeding season, and that they are due to the colour of the reproductive glands showing through the carapace. Such a phenomenon is at any rate described by Risso for *Bathynectes longipes.* He states (1816, pp. 30, 31): "La femelle, dans le temps des amours, est ornée de deux grandes taches d'un rouge foncé sur la partie antérieure du têt." The eggs of the latter species are described as "d'un rouge aurore," which would sufficiently account for the red colour of the ovarian regions before deposition of the ova; those of *P. nasutus* are described as "d'un jaune doré." Risso states that the eggs of *P. nasutus* are laid in May and August.

5. Sand-burrowing Habits.

The habits of *Portumnus nasutus* have hitherto been very imperfectly described. Risso (1816, pp. 25–31) states simply that at Nice the crab inhabits "la région des polypiers corticiféres" (p. 25), or "la région des coraux" (p. 31). Latreille's specimen (1825, p. 151) was obtained by D'Orbigny on the coast of La Vendée, which probably implies a sandy habitat, especially as Latreille's specimens of "*Platyonichus variegatus*" (*Portumnus latipes*) were obtained by the same naturalist on the same coast (*Nouv. Dict. d'Hist. Nat.*, 1818), and the latter species is known to have sand-burrowing habits.

My own observations are, however, unequivocal. The specimens were found burrowing in coarse shelly gravel, and when the crabs were introduced into an aquarium containing a deep layer of the same gravel they were observed to burrow into it at once with extreme agility until their bodies were completely covered to a depth of an inch or more. The act of burrowing is effected by means of the hinder thoracic legs, as is usual among Portunids. The crabs can also burrow in fine siliceous sand.

When imbedded, *P. nasutus* seems always to adopt a nearly horizontal position—not the upright attitude exhibited by *Corystes cassivelaunus* (this Journal, 1896, p. 223). The anterior part of the body is, however, generally a little higher than the posterior.

6. Respiratory Currents.

Under these circumstances, *Portumnus nasutus* exhibits a reversed water-current through its branchial chamber, though this is much more difficult to demonstrate in the present species than in the case of *Corystes.* The method I adopted was as follows:—

The depth of gravel in the aquarium was so regulated that the crab could not burrow far beneath the surface. The fragments of sand and shell which lay upon the front of its carapace and upon its interorbital lobe were then gently removed, one by one, with a pair of fine forceps, until the aperture of the buccal frame was exposed. These proceedings were, however, incessantly watched by the crab, which, not unnaturally, did not hesitate to disturb my preparations whenever it conceived that there was due cause for alarm. I therefore took the precaution to leave some fragments of shell over its eyes, and thus did not seriously disturb its impression that it was safely ensconced. I eventually succeeded in getting the crab so suitably situated that, on the addition of a little black-coloured water by means of a pipette to the region in front of the crab's maxillipeds, I had the satisfaction of seeing the water sucked inwards on both sides, to reappear again in a pair of streams at the base of the chelipeds. The two exhalant streams rose above the surface of the sand in a pair of clouds, one on each side of the body. Suddenly, and without warning, the normal current was set up, and then the lateral clouds of inky water were rapidly sucked in again on each side, to re-emerge again a second or two afterwards in a continuous stream in front of the mouth. Without this kindly cooperation on the part of the crab it would have been difficult, if not impossible, to get so successful a demonstration of the reversal of the currents. One of the most interesting phenomena presented by this crab is indeed the frequency with which, when under observation, it will alternate the direction of the respiratory currents.[*] It may even suspend the respiratory currents altogether for long intervals; *e.g.*, for as long as fifty-five seconds. At such times there is absolutely no movement in the surrounding water.

7. Utility of Specific Characters.

The interorbital prolongation of the frontal area, which gives both its name and most peculiar feature to the species *Portumnus nasutus*, is a feature usefully correlated with a habit of burrowing in coarse shelly gravel. It acts as an efficient buckler for the protection of the anterior sense-organs; but its unusual size and its downward bend seem to be more directly correlated with the reversal of the branchial currents, which I have shown to take place when the crab is imbedded. The advantage of reversal in the present case is a point to which I shall recur when dealing with the phenomenon in a more general manner; but, granted the reversal, the utility of the possession of a stout triangular shelf over the inhalant orifices is obvious after a study of the animal s habits and of the nature of the objects amid which the crab excavates its dwelling-place. In *Corystes,* which lives in fine sand, the inhalant antennal tube has been shown (1896) to subserve the double purpose of a supply pipe and a sieve. In *P. nasutus* a sieve is unnecessary so long as the crab inhabits coarse shell-gravel, the fragments of which are too large to enter the respiratory channels; and this appears to be the specific habit of the crab. But if the anterior inhalant apertures (during reversal) were altogether unprotected, the pointed fragments of shell might easily penetrate the inhalant orifices (during reversal), and so occlude their lumen. Such occlusion would prevent the crab from burrowing in the kind of material most suitable to its respiratory organisation, and thus expose the animal to increased risks of destruction by its ever-watchful enemies among fishes. The overhanging buckler provided by the prominent frontal lobe acts, however, as a very efficient means of supporting the shell-fragments well above the inhalant orifices—a function the existence of which I do not throw out as an academical suggestion, but the value of which I had frequent opportunities of observing and appreciating in my aquaria.

---

[*] Probably to eject distasteful particles. This is undoubtedly the explanation of similar phenomena in the case of *Corystes*. (See this Journal, vol. iv. 1896, p. 230.)

The interorbital lobe of *P. nasutus* is remarkably similar to the frontal protuberance of *Carcinus maenas* in the *Megalops* stage, which becomes reduced in later stages of development. Since I have found no indications of a reversal of the respiratory currents in the latter species, I am inclined to believe that the retention of this larval feature in *P. nasutus* is to be correlated with the reversal of the currents which occurs, as I have shown above, in this type; while its eventual loss in *Carcinus maenas* is to be indirectly attributed to the lack of any further use for it after the larval stages. The larval forms of *P. nasutus* are at present, however, unknown, and it is impossible to support this view with the necessary embryological facts.

The other specific characters of *P. nasutus* (viz., breadth of carapace, retention of two supra-orbital fissures, mobility of basal joint of second antenna) are not new features acquired within the history of the present species, but are merely heirlooms from Portunid ancestors of less specialised habits. It is not their presence in *P. nasutus* which is to be accounted for, but their absence in *Portumnus latipes*. The elucidation of those features will be attempted in a subsequent article dealing with the habits of the latter species.

In conclusion I may add that a good figure of *P. nasutus* is given in Costa's classical memoir on the fauna of the Bay of Naples (1853).

BIBLIOGRAPHY.

Bell, T.—l.c. (1853).

Carus, J. Victor.—*Prodromus Faunæ Mediterraneæ.* Stuttgart, 1885.

Costa, O. G.—*Fauna del Regno di Napoli*, 1836. *Addizioni a' Decapodi Brachiuri*, February, 1853, pp. 14, 15, Tav. 6, fig. 4.

Dana, J. D.—"Crustacea." *U.S. Exploring Expedition*, vol. xiii. 1852.

Garstang, W.—1. "The Habits and Respiratory Mechanism of Corystes cassivelaunus." *This Journal*, iv. pp. 223–232. 1896.

„ 2. "On the Function of certain Diagnostic Characters of Decapod Crustacea." *Rep. Brit. Ass. Liverpool*, 1896, pp. 828–830.

Latreille, M.—1. *Nouv. Dict. d'Hist. Nat.* 1818.

„ 2. *Encycl. Méthodique*, x. 1825.

Leach, W. E.—1. *Trans. Linn. Soc.*, xi. pp. 306–400. 1815.

„ 2. *Malac. Podoph. Brit.* 1815.

Milne-Edwards, H.—*Hist. Nat. des Crustacés.* 1834.

Risso, M.—*Hist. Nat. des Crustacés des environs de Nice.* 1816 (Plate I., fig. 2).

The Distribution of Marine Plankton.

In order to endeavour to co-ordinate the work of the many naturalists who make use of the tow-net round the coasts of the British Isles during the year, the following circular has been issued. The list of organisms, upon the presence or absence of which information is desired, contains only such as can be quite easily recognised. The scheme must be regarded as more or less experimental for this year, with a view to finding out what can be done in this direction.

Marine Biological Association of the United Kingdom.

THE LABORATORY, PLYMOUTH,
December 30th, 1896.

SIR,—Many of the organisms commonly found in the plankton of the sea around the British coast exhibit remarkable variations in their relative abundance at particular localities from year to year, but little is known as to the extent and causes of such variations. As a number of naturalists make use of the tow-net at many places round the coast, especially during the summer, much valuable information would be obtained if in all cases records were kept of the presence or absence of a limited number of the commoner species, and these records subsequently brought together.

In the hope that you may be willing to assist in obtaining such information, I enclose a short list of organisms, the presence or absence of which I would ask you to record at any locality and as often as you may be using the tow-net during the year 1897. The records may be forwarded to me from time to time, and all should be sent in before January 31st, 1898.

Additional copies of the list will be sent, if desired, and your assistance is requested in inducing other naturalists to co-operate in making the records.

I am, Sir, yours faithfully,

E. J. ALLEN,
Director.

LIST OF SPECIES.

List of Species to be recorded whenever and wherever possible, during the year 1897:—

Halosphaera viridis.
Noctiluca miliaris.
Aurelia aurita (including *Ephyrae*).
Agalmopsis.
Muggiæa atlantica.
Hormiphora plumosa.
Beroe.
Tomopteris.
Anomalocera Patersoni.
Doliolum.
Salpa.

Where the generic name only is given in the above list, the specific name of the specimens taken should be added. Should any doubt exist, preserved specimens should be kept.

In making a record the following should be stated:—

Date.
Hour.
Locality. (With as much accuracy as possible.)
Depth. (Depth of water, and maximum depth at which net has been worked.)

Quantity
- 0. Absent.
- 1. Few only.
- 2. Moderately plentiful.
- 3. Exceptionally abundant.

Observations on the temperature of the sea, and notes on wind, tide, etc., will also be of value.

Records to be sent in before January 31st, 1898, or forwarded from time to time to the Director, Marine Biological Association, Plymouth.

An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish.* Revision of Tables.

By

Ernest W. L. Holt.

About a year subsequent to the appearance of my paper on the Grimsby Trawl Fishery my attention was directed to certain arithmetical errors in the table on pp. 406 and 407 (pp. 70 and 71 of the Reprint). These errors are in truth, considerable, though fortunately not of a nature to affect the arguments brought forward in the text, as will appear to such of my readers as may be at pains to compare the revised edition with the original.

Although I have no intention of seeking to evade the responsibility for the figures published under my name, I may ask, nevertheless, to be allowed to advert briefly to the circumstances under which they went to press. At the time my paper was in preparation I was suffering from an illness that ultimately compelled me, with much regret, to sever my connection with the Association; and when it seemed advisable to expand my original statistics of "boxes" into columns of other quantities, I found my eyesight unequal to the cyphering thereby entailed. I was therefore obliged to confide the calculations, in great part, to other hands, with results sufficiently disastrous to my own reputation for accuracy.

The revision of the tables has brought to light two errors, which are not those of arithmetic, and for which the responsibility is entirely my own. In the entries for June, July, and August, 1892, it has been explained that 1000 cwt. was subtracted from the Board of Trade returns, as representing approximately the quantity of fish landed from Iceland during the said months. My intention, though not clearly explained in the text, was to subtract the amount from the aggregate; but in the tables it was inadvertently taken from each separate month.

---

* *Journ. Mar. Biol. Assoc.*, vol. iii. No. 5, Special Number, pp. 339-448. Reprinted under the above title. 1895.

In the present edition this item will be found to have been altered in accordance with the actual conditions, the amount subtracted being divided between the three months in proportions which correspond roughly with the relative abundance of Iceland fish during the period concerned. The figures 49,000 in column i were a misprint for 41,000—the Board of Trade total. A further error appears to have been made in the number of boxes for June, 1893, and this has accordingly been altered to the number originally published in the Journal of the Association, vol. iii. p. 124.

The table on p. 410 (Reprint, p. 74) is dependent on the calculations in the former table, and is therefore vitiated by the errors alluded to. It happens, however, that the revision of this table only brings into greater prominence the destruction of undersized fish.

My attention has recently been drawn to the absence of any definite statement in my text as to the method by which the averages of number of fish in boxes of different qualities were deduced. At this lapse of time I regret that I am unable to lay hands upon the original figures, and can only state that I deduced averages from the contents of a large number of boxes of each quality counted during the earlier period of my work, and checked the results so obtained from time to time during the later years; and in order to run no risk of exaggerating the proportion of undersized fish, I actually made use of averages which somewhat underestimated such proportion.

It remains for me to express my indebtedness to the Association for publishing this corrected version of my tables (which my own circumstances did not allow of my undertaking), and to Professor Weldon and Mr. E. J. Allen for the revision of my figures.

Table showing the Weight, Bulk, and approximate Number of Plaice
fishing power (in voyages of steam-trawlers)

The terms "large" and "small" in this table refer only to the market designation under

	ALL DEEP-SEA GROUNDS.			NORTH SEA.		
	Total.			Total.		
	Cwt.	Boxes.	Fish.	Cwt.	Boxes.	Fish.
1892.	i	ii	iii	iv	v	vi
April	11,000	9,778	1,253,200	11,000	9,778	1,253,200
May	12,000	10,667	1,191,200	12,000	10,667	1,191,200
June	41,000	36,355	4,697,450	11,075	9,844	1,504,900
July				17,650	15,689	1,877,750
August				11,275	10,022	1,290,800
September	15,000	13,333	1,510,900	15,000	13,333	1,510,900
October	20,000	17,778	1,822,050	20,000	17,778	1,822,050
November	20,400	18,133	1,813,300	20,400	18,133	1,813,300
December	11,000	9,778	977,800	11,000	9,778	977,800
1893.						
January	10,000	8,889	892,050	10,000	8,889	892,050
February	7,600	6,756	680,250	7,600	6,756	680,250
March	10,000	8,889	888,900	10,000	8,889	888,900
April*	12,213	10,833	1,471,650	11,963	10,633	1,463,650
May	23,580	20,439	2,953,020	17,726	15,756	2,765,700
June	22,919	19,555	2,313,250	13,731	12,205	2,019,250
July	29,760	25,190	2,259,290	15,540	13,814	1,804,250
August	22,992	19,675	1,806,610	14,424	12,821	1,532,450
September	13,864	12,296	1,334,000	13,552	12,046	1,324,000
October	18,215	16,191	1,710,450	18,215	16,191	1,710,450
November	12,621	11,219	1,244,300	12,621	11,219	1,244,300
December	5,141	4,570	470,050	5,141	4,570	470,050
1894.						
January	5,021	4,463	477,650	5,021	4,463	477,650
February	4,134	3,674	377,900	4,134	3,674	377,900
March	9,378	8,336	1,061,150	9,378	8,336	1,061,150
Total for year ending March, 1894	179,838	156,441	17,479,320	141,446	125,728	16,250,800
April	21,179	18,705	3,068,490	19,822	17,619	3,025,050
May	17,914	15,577	2,174,230	14,018	12,460	2,049,550
June	18,277	15,939	2,139,720	14,829	13,181	2,029,400
July	17,880	15,559	1,752,160	14,119	12,550	1,631,800
August	19,441	17,206	1,886,590	18,608	16,540	1,859,950
September	19,466	17,303	1,871,300	19,466	17,303	1,871,300
Total for six months	114,157	100,289	12,892,490	100,862	89,653	12,467,050

* Totals previous to this date are taken from official returns.

landed at Grimsby by deep-sea trawlers, and (col. xvi) *the diversion of from the North Sea grounds in each month.*

which the fish so enumerated are sold. *Vide* text, pp. 402 and 403 (pp. 66 and 67 of Reprint).

North Sea.						Iceland.			
Large.			Small.			Cwt.	Boxes.	Fish.	Voyages.
Cwt.	Boxes.	Fish.	Cwt.	Boxes.	Fish.				
vii	viii	ix	x	xi	xii	xiii	xiv	xv	xvi
8,935	7,942	794,200	2,066	1,836	459,000	..	...	...	...
11,067	9,837	983,700	934	830	207,500	...	...	...	...
7,171	6,374	637,400	3,904	3,470	867,500	...	...	...	...
15,334	13,630	1,363,000	2,316	2,059	514,750	1,000	800	24,000	?
9,110	8,098	809,800	2,165	1,924	481,000	...	...	...	...
13,668	12,149	1,214,900	1,332	1,184	296,000	...	...	...	...
19,668	17,483	1,748,300	332	295	73,750	...	...	...	...
20,400	18,133	1,813,300	...	...	...	...	...	...	...
11,000	9,778	977,800	...	...	...	...	...	...	...
9,977	8,868	886,800	24	21	5,250	...	...	...	...
7,566	6,725	672,500	35	31	7,750	...	...	...	...
10,000	8,889	888,900	...	...	...	...	...	...	...
—	—	—	—	—	—	—	—	—	—
8,960	7,964	796,400	3,003	2,669	667,250	250	200	8,000	2
8,800	7,822	782,200	8,926	7,934	1,983,500	5,854	4,683	187,320	20
7,740	6,880	688,000	5,991	5,325	1,331,250	9,188	7,350	294,000	30
12,369	10,995	1,099,500	3,171	2,819	704,750	14,220	11,376	455,040	36
12,546	11,152	1,115,200	1,878	1,669	417,250	8,568	6,854	274,160	21
12,656	11,250	1,125,000	896	796	199,000	312	250	10,000	1
17,530	15,582	1,558,200	685	609	152,250	...	...	...	...
11,703	10,403	1,040,300	918	816	204,000	...	...	...	...
5,043	4,483	448,300	98	87	21,750	...	...	...	...
4,786	4,254	425,400	235	209	52,250	...	...	...	...
4,055	3,604	360,400	79	70	17,500	...	...	...	...
7,671	6,819	681,900	1,707	1,517	379,250	...	...	...	...
113,859	101,208	10,120,800	27,587	24,520	6,130,000	38,392	30,713	1,228,520	110
10,348	9,198	919,800	9,474	8,421	2,105,250	1,357	1,086	43,440	7
7,991	7,103	710,300	6,027	5,357	1,339,250	3,896	3,117	124,680	25
9,494	8,439	843,900	5,335	4,742	1,185,500	3,448	2,758	110,320	21
11,293	10,038	1,003,800	2,826	2,512	628,000	3,761	3,009	120,360	19
17,063	15,167	1,516,700	1,545	1,373	343,250	833	666	26,640	5
18,408	16,363	1,636,300	1,058	940	235,000	...	...	...	...
74,597	66,308	6,630,800	26,265	23,345	5,836,250	13,295	10,636	425,440	77

Table showing the Numbers and Proportion of Plaice of different sizes landed at Grimsby by deep-sea trawlers in one year.

	Sexually				13 inches and above.		Below 13 inches.	
	Mature. 17 inches and above.		Immature. Below 17 inches.					
	No.	%	No.	%	No.	%	No.	%
	i	ii	iii	iv	v	vi	vii	viii
1893. April	557,480	38	906,170	62	783,485	53	680,165	47
May	547,540	20	2,218,160	80	902,330	33	1,863,370	67
June	481,600	24	1,537,650	76	752,325	37	1,266,925	63
July	769,650	43	1,034,600	57	1,060,025	59	744,225	41
August	780,640	51	751,810	49	1,045,405	68	487,045	32
September	787,500	59	536,500	41	1,032,400	78	291,600	22
October	1,090,740	64	619,710	36	1,417,605	83	292,845	17
November	728,210	59	516,090	41	956,670	77	287,630	23
December	313,810	67	156,240	33	405,645	86	64,405	14
1894. January	297,780	62	179,870	38	388,085	81	89,565	19
February	252,280	67	125,620	33	326,110	86	51,790	14
March	477,330	45	583,820	55	651,635	61	409,515	39
Total for year	7,084,560	44	9,166,240	56	9,721,720	60	6,529,080	40

Director's Report

THE number of workers who have occupied tables at the Laboratory during the winter months has not been large. It becomes increasingly evident that the amount of work which can be carried on during this period of the year must depend upon the number of naturalists who can be employed by the Association to undertake general or special investigations. At the present moment our funds will only permit of the employment of one such naturalist, who is engaged in fishery investigations. My own time is so much occupied with administrative and other duties, that comparatively little of it can be devoted to scientific research. It may be worth while to point out once more that whilst the United States Commission of Fish and Fisheries is allowed an annual sum of £35,000 for salaries alone, a considerable portion of which is devoted to the payment of naturalists engaged in research, the total income of the Marine Biological Association amounts to only about £2000 a year.

Since the publication in August of the last number of the Journal, the following naturalists have visited the Laboratory :—

Brebner, G., August 1st to October 6th, 1896 }
December 30th, 1896, to Jan. 18th, 1897 } (*Marine Algæ*).
Brumpt, E. (Paris), September 8th to 24th (*General Zoology*).
Church, A. H., B.A., July 8th to September 30th (*Marine Algæ*).
Goodrich, E. S., B.A., January 4th to 11th (*Holothurians*).
Menon, R., August 24th to October 13th (*Nervous System of Mollusca*).
Riches, T. H., B.A., January 13th to December 10th (*Nemertines*).
Scott, S. D., B.A., July 28th to November 20th (*Ascidians*).

Early in December we received a visit from a party of four fishermen, who, under the auspices of the Technical Education Committee of the Aberdeenshire County Council, were making a tour of the various fishing centres of England and Scotland, accompanied by Mr. Robert Turnbull, B.Sc., who acted as instructor. We arranged for two lectures on the Natural History of Fishes to be given for the benefit of the party, and assisted them as much as possible in seeing the various methods of fishing practised in this port.

Mr. F. B. Stead, who has been working at food fishes at Plymouth, has left for Naples, where he is at present occupying the Cambridge

University table. Mr. S. D. Scott, of King's College, Cambridge, is temporarily assisting me to carry on the fishery investigations. The work on the east coast, commenced by Mr. Holt and subsequently continued by Mr. Cunningham, has now ceased owing to lack of the necessary funds for its maintenance.

The experimental trawling in the bays on the Devonshire coast has been continued during the autumn and winter. The results of the trawlings in January show clearly, as was to have been expected, that the larger plaice have left, probably for the spawning grounds, whilst the fish from the estuaries and from close inshore have come out into the bays. Thus in Teignmouth Bay, whereas in October and December 4 per cent. only of the plaice were 7 inches and under, in January the proportion at this size and under had increased to 32 per cent.

In connection with studies on the distribution of fish eggs, larvæ, and young fish, a series of experiments has been started for determining the surface drift in the western portion of the English Channel by means of floating bottles. The experiments are similar to those which have been made by Prof. Herdman in the Irish Sea, and by the Scottish Fishery Board in the North Sea; but we have adopted a bottle of somewhat larger size, in order to counteract as much as possible the direct action of the wind upon the bottle itself. Ordinary egg-shaped soda-water bottles are being used, weighted with shot in such a way that the bottle floats vertically, the shot being kept in place by being imbedded in solid paraffin. The thanks of the Association are due to Admiral the Hon. Sir E. R. Fremantle, Commander-in-Chief at Devonport, who has kindly arranged for bottles to be put overboard by the torpedo-boat destroyers cruising in the neighbourhood. This will enable us to carry out the experiments in a much more satisfactory way than would otherwise have been possible. Owing to the rugged nature of the coast, I do not anticipate that we shall recover so large a percentage of the bottles as was the case in Prof. Herdman's and the Scottish experiments.

With a view to obtaining information as to the distribution of marine plankton, a scheme has been arranged to endeavour to co-ordinate the work of the many naturalists who frequently make use of the tow-net around the British coasts. A further account of this will be found on p. 408.

The dredging and trawling work on the grounds between the Eddystone and Start Point was continued during last summer, and the results of about seventy hauls have been worked out. It is hoped that the results of this work, which has been carried on regularly for two summers, will shortly be ready for publication.

In promising to place on the estimates for the year 1897–98 the usual grant of £1000 to the Association, the Lords Commissioners of H.M. Treasury have made it a condition of the grant that the Association will give all the assistance in its power to the Inspectors of Irish Fisheries in investigations which they desire to be made on the habits, etc., of the mackerel visiting the Irish coast. In connection with this subject, a report is being prepared upon the present state of knowledge of the natural history of the mackerel in all parts of the world.

Mr. Cunningham's book on the *Natural History of the Marketable Marine Fishes of the British Islands*, which has been published for the Association by Messrs. Macmillan & Co., has been very favourably noticed by the Press, and there seems little doubt but that it will be regarded as a standard popular work on the subject.

The system of filtering sea-water through layers of blanketing, which was devised in connection with the hatchery at Dunbar, has been adopted for the Aquarium here with satisfactory results. The supply of water from the sea has been greatly interfered with owing to the pipe which brings the water to the ejector having been damaged by the stranding of the steamship *Ariel* on the rocks below the Laboratory. The pipe has been repaired, and we are advised that the owners are liable for the damage done.

The *Busy Bee*, which has now been in regular use for twelve months, continues in good condition, and has given very little trouble in the way of repairs. We have found her coal consumption remarkably low, and the expense of running her has been considerably less than was anticipated. We are now having a compact trawling winch, capable of carrying a drum of wire-rope, built for her, which will greatly increase her usefulness.

I regret to say that the whole of the money for this vessel has not yet been subscribed. With the necessary fittings, including the winch, a sum of nearly £700 has been spent. Towards this amount, as will be seen from the list which follows this Report, £537 14s. has been given. We are very anxious that the balance should be met during the present financial year, which ends in May.

E. J. ALLEN.

February, 1897.

Steamboat Fund.

LIST OF SUBSCRIPTIONS TO JANUARY, 1897.

	£	s.	d.
The Worshipful Company of Fishmongers	105	0	0
The Royal Society	100	0	0
J. P. Thomasson, Esq.	100	0	0
The Worshipful Company of Drapers	52	10	0
,, ,, ,, Grocers	50	0	0
,, ,, ,, Mercers	26	5	0
,, ,, ,, Skinners	21	0	0
,, ,, ,, Goldsmiths	20	0	0
The Earl of Ducie	10	0	0
Sir Henry Thompson	10	0	0
E. L. Beckwith, Esq.	5	5	0
Mrs. E. S. Heywood	5	5	0
The Earl of St. Germans	5	0	0
R. Assheton, Esq.	5	0	0
G. Fry, Esq.	5	0	0
J. Mackrell, Esq.	5	0	0
E. Grove, Esq.	3	0	0
S. F. Harmer, Esq.	2	2	0
S. Makowski, Esq.	2	2	0
W. H. St. Quintin, Esq.	2	2	0
A. O. Walker, Esq.	2	2	0
W. I. Beaumont, Esq.	1	1	0
	£537	14	0

OCT 1 1897

INDEX.

A.

Acanthias vulgaris, 41, 45
Achrochætium endophyticum, 286, 287
Actinotrocha, 171
Agalmopsis, 409
Aglaophenia, 49
— *Helleri*, 153
— *pluma*, 153
Ahnfeltia plicata, 287
Albunea symnista, 232
Alcyonium digitatum, 38, 51
Algological Notes, 179, 286
Allen, E. J., see contents
Amaræcium punctum, 84
Amphicodon amphipleurus, 50
Amphinema dinema, 169
Amphioxus lanceolatus, 34, 171, 250
Anchorella emarginata, 163
— *paradoxa*, 163
— *quadrata*, n. sp., 163
— *triglæ*, 163
— *uncinata*, 163
Anchovy, 134
Anguilla acutirostris, 375, 377
— *latirostris*, 376, 377
— *mediorostris*, 376
— *vulgaris*, 375
Anomalocera Patersoni, 175, 409
Aplidium zostericola, 84
Aplysia punctata, 51
Acrochætium microscopicum, 287
Arenicola, 51
Arnoglossus laterna, 380
Asterias glacialis, 268
Astropecten aurantiacus, 267
Atelecyclus heterodon, 232, 397, 399
Aurelia aurita, 50, 409

B.

Balance-sheet, 86, 307
Balænoptera Sibbaldii, 237
Baltic, Northern species in, 237, 255
— Southern species in, 236
Bassett-Smith, P. W., see Contents.
Bathynectes longipes, 397
— — respiratory process, 398
Beroë, 170, 409
Bethe, A., see Contents
Bidder, G., see Contents
Biddulphia mobilensis, 383
Bionomics, contributions to Marine, 223, 396
Bolina hydatina, 50
Bougainvillia, see *Margelis*
Brachiella bispinosa, 163
— *impudica*, 162
— — var. *parva*, 163
— *insidiosa*, 162
— *thynni*, 162
— *triglæ*, 163
Brachyura Oxystomata, phylogeny, 400
Brebner, G., see contents
Brill on the German Grounds, 107
— size limit for, 143
— size and maturity, 32
Browne, E. T., see Contents
Brown Ridges, comparison with German Coast, 131
Burrowing Crabs, function of antero-lateral denticulations in carapace of, 396
Burrowing habits of *Portumnus nasutus*, 404
Butler, G. W., see Contents

C.

Calanus finmarchichus, 382
Caligidæ, 156
Caligus brevipedis, n. sp., 157
— *curtus*, 157
— *diaphanus*, 156
— *elegans* (?), 156
— *gurnardi*, 157
— *minimus*, 156
— *Mülleri*, 157
— *rapax*, 156, 177
— *scomberi*, n. sp., 156
— *tenuis*, 156
Callinectes sapidus, 400
Callocolax neglectus, 180
Calycella syringa, 148
Campanularia flexuosa, 147
— *fragilis*, 147
— *neglecta*, 147
Candace pectinata, 177
Carcinus, abnormal specimen, 144
Catometopa, burrowing habits, 396
Cecrops Latreillei, 159
Centropages hamatus, 236
— *typicus*, 175, 176
Ceratium divergens, 382
— *furca*, 382
— *fusus*, 382
— *tripos*, 175, 176, 381
Cetochilus septentrionalis, 175, 176
Chætoceros atlanticus, 383
— *borealis*, 383
— *curricetus*, 383
— *didymus*, 383
— *grœnlandicus*, 384
— *socialis*, 384
— *scolopendra*, 384
— *teres*, 384
Chætopterus, 170
Chlorophyceæ, 179, 286
Chondracanthina, 161
Chondracanthus clavatus, n. sp., 161
— *cornutus*, 161
— *lophii*, 162
— *merluccii*, 162
— *soleæ*, 161
— *triglæ*, 161
— *Zei*, 162
Chrysaora isosceles, 50
Circinalium concrescens, 84
Cladophora hirta, 286
Clausia elongata, 175, 176, 177
Clavella mulli, 159
Cleve, P. T., see Contents
Closure of Inshore areas to trawlers 366
Clupea sapidissima, 209
Clytia Johnstoni, 147
Cockles, regulations for taking, 394
Colaconema Bonnemaisoniæ, 179, 180
— *Chylocladiæ*, 179, 180
— *reticulatum*, 179, 180
Conchocelis rosea, 179
Conilera cylindracea, 265
Corycæus anglicus, 174–177
Corymorpha nutans, 49, 50, 84
Corystes cassivelaunus, burrowing habits, 227
— — respiratory currents, 228
— — structural peculiarities, 224
— — systematic position, 223
Coscinodiscus concinnus, 382
Crabs and Lobsters, protection of, 182
— — regulations for capture, 392
— size limit for, 186
— spawning period, 184
Crangon vulgaris, 51
— — see also Shrimp
Cruoria adhærens, 180
— *rosea*, 180, 181, 286, 287
Cruoriella Dubyi, 180
Cruoriopsis cruciata, 286, 287
— *Hauckii*, 286, 287
Ctenophores, 174
Cunningham, J. T., see Contents
Cuspidella grandis, 149
Cuthona aurantiaca, 51, 75
Cyanophyceæ, see *Myxophyceæ*
Cyclometopa, burrowing habits, 396
Cycnus pallida, 159
Cyphonautes, 175, 177

D.

Dab, distribution, 343
— ovaries, 47
— see also *Pleuronectes limanda*
Danish Report, 375
Dasya coccinea, 287
Depastrum cyathiforme, 50
Desmarestia Dresnayi, 179, 180
Destruction of Immature Fish, Revision of tables, 410

Dias longiremis, 175
Dichelestina, 159
Dictyocha speculum, 383
Diphasia tamarisca, 165
Diphyes truncata, 236
Dipurena halterata, 169
Director's Report, 76, 219, 300, 415
Distaplia rosea, 84
Distomum insigne, 265
Distribution of Fish in the North Sea, causes of, 133
Distribution of the Waters of the North Sea in different months of the year, 243
Distribution of Marine Plankton, 408
Ditylum Brightwellii, 383
Doliolum tritonis, 169-176, 409
Donations and Receipts, 85, 305
Dondersia banyulensis, 166
Doris maculata, n. sp., 167
Dumontia filiformis, 288
Dunbar Hatchery, 373

E.

Ebalia, 398
Echinocardium pennatifidum, 165
Echinoderm larvæ, 170
Echinorhinus spinosus, 264
Ectocarpus terminalis, 179
— *velutinus*, 179
Eel, 375
— reproductive maturity of, 87
— ripe ovaries of, 87
— spawning period, 88
Elytrophora brachyptera, 158
Ephyræ, 50, 409
Euchalarodus Putnami, 333
Euchilota, 169
Eudendrium album, n. sp., 146
Eudendrium capillare, 49
— n. sp. 49
Euphausia inermis, 236
Eupolia curta, 166
Eurynome aspera, 396
Evadne Nordmanni, 175
— *spinifera*, 382

F.

Faunistic Notes, 48, 164
Fiber zibethicus, 271
Fish, different sizes of the same species at different parts of its habitat, 260
— distribution on South Coast of Devon, 90
— eggs, artificial hatching, 203
Fisheries Committees, regulations, 386
— Districts, 386
Flat-fishes, influence of light on lower sides of, 53
Florideæ, 179, 286, 287
Flounders, Duncker's North Sea Specimens, 339
— from Greifswald, 338
— — Niendorf and Kiel, 339
— — the Baltic, 338
— specific characters, 294
— synonyms, 340

G.

Galeus vulgaris, 43
Garstang, W., see Contents
Garveia nutans, 49
Glœosiphonia capillaris, 288
Gomontia polyrhiza, 179
Gonothyræa Lovèni, 148
Grimsby, observations at, 108
Günther, R. T., see Contents

H.

Halcampa, sp., 50
Halecium tenellum, 83, 149
Halosphæra viridis, 382, 409
Harpacticus chelifer, 177
Heligoland, report of biological station, 380
— southern species of fish at, 247, 251
Hero formosa, 51
Herring in North Sea, 239
— migrations in North Sea, 259
— rate of growth, 374
Heterocordyle Conybeari, 165
Hippa talpoida, 232
Hodgson, T. V., see Contents
Holt, E. W. L., see Contents
Homarus Americanus, 60
— vulgaris, 60, 62
— — see also Lobster
Hormiphora plumosa, 175, 409
Hull, observations at, 114

Huxley, The Right Hon. T. H., obituary notice, 1
Hyas araneus, 34, 35
Hydroids of Plymouth, 146
Hyella cæspitosa, 286
Hyperoche Kröyeri, 236

I.

Inachus, 35
Iphis, epibranchial spines, 400
Ixa, epibranchial spines, 400

L.

Lafoea dumosa, 166
Lankester, E. R., see Contents
Lar Sabellarum, 169
Lemon Dab, size and maturity, 31
Lepeophtheirus obscurus (?), 157
— *pectoralis*, 158
— *pollachius*, n. sp., 157
— *stromii*, 157
Leptocephalus brevirostris, 379
— *Morrisii*, 73
Leptonema fasciculatum, 179
Lernæodea, 160
Lernæonema, 160
— *encrasicola* (?), 160
— *monillaris*, 160
Lernæopodidæ, 162
Lernæopoda galei, 162
— *salmonea*, 162
Lernanthropus Kroyeri, 159
Lernea, 160
— *branchialis*, 160
— *lusci*, n. sp., 160
Limanda aspera, 343
— *ferruginea*, 343
Limacina balea, 237
Liopsetta glabra, 333
Lirianthu appendiculata, 169
List of Governors, Founders, and Members, 308
Lithoderma fatiscens, 286
— *simulans*, 286
Lithothamnion Strömfeltii, 287
Lizzia blondina, 169
Lobsters, "black," 62
— nerve elements of embryonic, 70
— Newfoundland hatchery, 69
— number of eggs laid by, 66
— ovary, 66
Lobsters, protection of, 182
— rate of destruction of larval, 68
— regulations for capture, 392
— reproduction of, 60
— size limit for, 186
— spawning period, 63, 183
— tables showing percentage of egg-bearing females (Ehrenbaum), 64
— see also *Homarus vulgaris*
Longipedia coronata, 177
Lowestoft, observations at, 121
Lupa hastata, 400
Lyngbya Meneghiniana, 179
Lyonsia norvegica, 166

M.

Mackerel, 134
— fishing at Lowestoft, 248
— in North Sea, 238
Magelona, 171
Margelis ramosa, 50
Mastigocoleus testarum, 179
Matuta, 397
Melobesia Lejolisii, 180
Mitraria, 171
Monstrilla Danæ, 176
Muggiæa atlantica, 170, 175, 409
Microscopic marine organisms in the service of hydrography, 381
Migration dependent on temperature, 249
Monroe, R. M., on sponge culture, 289
Mussels, regulations for taking, 394
Myxophyceæ, 179, 286

N.

Natica, defensive action against starfishes, 273
Nauplii, 176
Nerve elements of embryonic lobster, 70
Nitschia seriata, 384
Noctiluca miliaris, 169, 177, 409
North Sea investigations, 10, 97, 233
— — — details of hauls with trawl, 33
— — physical and biological conditions in, 233
— — physical conditions, 135, 257

North Sea investigations, southern species of fish entering at the north, 252
— — southern species of fish entering from the south, 247
Notes and Memoranda, 73
Nutting, C. C., see Contents

O.

Obelia, 175
— *geniculata*, 147
— *longissima*, 147
— *lucifera*, 170
Octorchis, 169
Oikopleura dioica, 175
Oithona spinirostris, 174–177
Opercularella hispida, n. sp., 148
— *lacerata*, 148
Ophiactis Balli, 165
Ophiura affinis, 165
Orthagoriscus mola, 379
Oscillatoria rosea, 286
Ostreobium Queketti, 179
Otter trawl, 114
Oxygen dissolved in sea water, 235, 238
Oxyrhyncha, 396
Oyster beds of Firth of Forth, 374
— culture, modern system, 363
Oyster culture of Romans, 360
Oysters, regulations regarding, 393

P.

Pandarus bicolor, 159
Paracalanus parvus, 174, 382
Paraphellia expansa, 165
Parasitic copepods on fish, 155
Parathemisto oblivia, 236
Parophrys quadrituberculatus, 331
Pelagic fauna, 168, 172
Penella sagitta (?), 160
Periwinkles, close season for, 395
Peyssonelia Harveyana, 287
— *Rosenvingii*, 287
— *rupestris*, 286
Phæophyceæ, 179, 286
Phialidium, sp., 50
Phormidium persicinum, 179
Phyllophora Traillii, 180
Pigment on the lower sides of flatfishes, 53
Pilidium, 170
Plaice of North Sea compared with other regions, 326
— difference in size in Start Bay and Teignmouth Bay, 94
— distribution, 330
— experiment on a piebald, 58
— food of, 19, 216
— in Danish waters, 213
— length and age, 136
— Natural History of, 15
— ovaries, 37, 47
— peculiarities on different fishing grounds, 315
— protective measures for, 25, 217
— rate of growth, 214
— spinulation of the scales, 323, 342
— tables showing variation, 344–359
— undersized, 22, 138
Plankton of Skagerack and Cattegat, 382
— procured by pumping, 385
Platessa drinensis, 333
— *glabra*, 333, 340
— *passer*, 340, 354
— *quadrituberculata*, 331
Platichthys stellatus, 341
Platyonichus nasutus, 402
Plectonema terebrans, 179
Pleuronectes asperrimus, 341
— *Bogdanovii*, 341
— *cicatricosus*, 341
— *flesus*, distribution, 338
— *Franklinii*, 333
— *glaber*, 333
— *glacialis*, 297, 330, 333, 354
— *italicus*, 340, 354
— *luscus*, 340, 354
— *Pallasii*, 331, 332
— *pseudoflesus*, 293, 297
— *quadrituberculatus*, 331
Plumularia Alleni, n. sp., 153
— *halecioides*, 83, 152
— *pinnata*, 149
— — origin of sex cells, 151
— — a sexual multiplication of, 152
Plutei, 176
Podon intermedius, 175, 176
Polygordius sp., 165
Polynoë, 170
Portumnus latipes, 402

Portumnus nasutus, systematic features, habits, and respiratory phenomena, 402
— *variegatus*, 403
Portunidæ, function of the carpal spine, 399
Portunus biguttatus, 402
Pseudocalanus elongatus, 382

R.

Raia clavata, 44
Ralfsia clavata, 179
— *disciformis*, 286
— *spongiocarpa*, 179
Rathkea octopunctata, 50
Report of Council (1894–95), 81
— — (1895-96), 302
Reports of Fishery Authorities, 203, 366
Respiratory current, reversal in *Portumnus nasutus*, 405
Rhizosolenia, 175
— *alata*, 383
— *gracillima*, 382, 383
— *styliformis*, 383
Rhodochorton membranaceum, 180, 287
— *minutum*, 180
Rhododermis elegans, 287
— *parasitica*, 180
Rhododiscus pulcherrimus, 180, 181
Rotifera, 171

S.

Salpa, 409
Sarcostyles, 150
Sarcodictyon catenata, 165
Sarsia pulchella, 50
Scales, development in plaice, 295
Scarborough, observations at, 112
Schiemenz, Dr. P., see Contents
Scottish Report for 1895, 366
Seining, regulations, 390
Sex-cells, origin in *Plumularia pinnata*, 151
Sexual character in flounder and plaice, 295
Shad, introduction in North America, 209
Shrimps and prawns, regulations for capture, 389
Sipunculus nudus, 51
Skageraek and Cattegat, difference in salinity, 234
Skeletonema costatum, 383
Smelt or sparling, regulations for capture, 392
Solea lutea, 41, 380
Sole, dates and times of spawning, 4
— food of, 124
— size-limit for, 142
— spawning in tanks of the Aquarium, 3
Solmaris, 169
Spadella bipunctata, 175, 176
Sponge-culture experiments, 191, 195, 289
— — of Buccich, 191
— — in Florida, 192
Sponge fishery of Florida, 189
— — projects for improvement of, 195
Sponges, rate of growth of, 201
— transport of, 199
Starfishes opening oysters, 266
Start Bay, fish caught in, 93
Stead, F. B., see Contents
Steamboat Fund, 418
Steenstrupia rubra, see *Corymorpha nutans*
Stylochoplana maculata, 166
Symploca atlantica, 286
Syncoryne eximia, 49
— *mirabilis*, 49, 84
— sp., 49

T.

Teignmouth Bay, fish caught in, 93
Temora longicornis, 175
Terebella, 170
Thalassiosira gravida, 384
— *longissima*, 383
— *Nordenskiöldii*, 384
Thalassiothrix Frauenfeldii, 383
Thalia democratica-mucronata, 171
Thuiaria articulata, 165
Tiaropsis, 50
— *diademata*, 83
Tomopteris onisciformis, 176, 409
Tornaria, 171–176
Trachinus draco, 126, 132
— *vipera*, 132
Trailliella intricata, 180
Trammel, Stake and Stop nets, regulations, 391

Trawling, details of hawls in North Sea, 38, 108, 128
— experiments in bays of S. Devon, 90
— with sailing vessels, 388
— with steam vessels, 387
Trebius caudatus, 158
Trigla cuculus, 44
— *gurnardus*, 44, 47
— *hirundo*, 39, 134
Triopa claviger, 51
Trochospheres, 175, 176
Trophonia, 46
Tubiclava lucerna, 166
Tubularia indivisa, 49
— *larynx*, 49
Turbot on the German Grounds, 107
— ovary, 211
Turbot, size limit for, 143
— size and maturity, 32

U.

Utility of Specific Characters in *Portumnus nasutus*, 405

V.

Variations and Relationship of the Flounder and Plaice, 293
Venus verrucosa, and Starfish, 292

W.

Whiting, 124
Willia stellata, see *Lar Sabellarum*

Z.

Zoœæ of *Carcinus*, 175
— *Porcellana*, 176

PLYMOUTH:
WILLIAM BRENDON AND SON,
PRINTERS.

JUST PUBLISHED.

Medium 8vo, 368 pages. 159 Illustrations and two Maps. Price 7s. 6d. net.

THE NATURAL HISTORY
OF THE
Marketable Marine Fishes of the British Islands.

Prepared by order of the Council of the Marine Biological Association expressly for the use of those interested in the Sea-fishing Industries,

BY

J. T. CUNNINGHAM, M.A.,

FORMERLY FELLOW OF UNIVERSITY COLLEGE, OXFORD;
NATURALIST ON THE STAFF OF THE MARINE BIOLOGICAL ASSOCIATION.

With Preface by

E. RAY LANKESTER, M.A., LL.D., F.R.S.,

PROFESSOR OF COMPARATIVE ANATOMY IN THE UNIVERSITY OF OXFORD;
PRESIDENT OF THE MARINE BIOLOGICAL ASSOCIATION.

CONTENTS.

PART I.—GENERAL.

CHAPTER

I.—History of Modern Investigations of the Subject.

II.—The Characteristics of valuable Marine Fishes and the Regions in which they live.

III.—The Generation of Fishes and their Fecundity.

IV.—The Eggs and Larvæ and their Development.

V.—Growth, Migrations, Food, and Habits.

VI.—Practical Methods of Increasing the supply of Fish.

PART II.—HISTORY OF PARTICULAR FISHES.

THE HERRING FAMILY:—The Herring. The Sprat. The Pilchard or Sardine. The Shads. The Anchovy.

THE SALMON FAMILY:—The Smelt.

THE EEL FAMILY:—The Eel. The Conger.

PART II.—HISTORY OF PARTICULAR FISHES—CONTINUED.

The Garfish or Guard-Fish Family.

The Flat-Fish Family :—The Plaice. The Common Dab. The Flounder. The Witch. The Lemon Dab, or Lemon Sole. The Halibut. The Long Rough Dab. The Sole. The Sand Sole, or French Sole. The Solenette, or Little Sole. The Thickback. The Turbot. The Brill. The Megrim. The Scaldfish, or Scaldback. The Top-knots.

The Cod Family :—The Cod. The Haddock. The Whiting. The Coal-Fish. The Pollack. The Ling. The Hake. The Rocklings. The Tusk, or Torsk. The Sand-Eels.

The Red Mullet Family.

The Sea Breams.

The Mackerel, or Tunny Family :—The Mackerel.

The Family of the Scads, or Horse-Mackerels.

The John Dory Family :—The Boar-Fish, or Cuckoo. The John Dory.

The Gurnard Family :—The Bullheads. The Gurnards.

Grey Mullets :—The Thick-Lipped Grey Mullet.

The Angler Family :—The Angler, or Frog-Fish.

The Blennies :—The Cat-Fish, or Sea-Cat.

The Sucker Family :—The Lump-Sucker. The Diminutive Suckers.

Appendix I. Appendix II. Index.

MACMILLAN & CO., Ltd.,
BEDFORD STREET, STRAND, LONDON.

PUBLICATIONS OF THE ASSOCIATION

Cloth 4to, 150 pp., 18 plates (12 coloured).

A TREATISE ON THE COMMON SOLE.

BY

J. T. CUNNINGHAM, M.A.,

Late Fellow of University College, Oxford; Naturalist to the Association.

Price to Members,* 20*s.*; to Non-Members, 25*s.*
From the DIRECTOR, The Laboratory, Plymouth, and through all Booksellers.

JOURNAL OF THE MARINE BIOLOGICAL ASSOCIATION.

OLD SERIES.

No. 1, AUGUST, 1887 (only a few copies left, reserved for Libraries).
No. 2, AUGUST, 1888. Price 1*s.*

NEW SERIES.—VOLUME I.

1889–90.

Royal 8vo, xx. *and* 472 *pp.,* 28 *plates.*

NEW SERIES—VOLUME II.

1891–92.

Royal 8vo, x. *and* 404 *pp.,* 14 *plates,* 12 *woodcuts, and* 10 *charts.*

NEW SERIES.—VOLUME III.

1893–95.

Royal 8vo, xxxviii. *and* 458 *pp.,* 5 *plates, and* 25 *woodcuts.*

NEW SERIES.—VOLUME IV. PARTS 1, 2, 3, 4.

Separate numbers, in wrappers, 3*s.* 6*d.*; to Members,* 2*s.* 8*d.*

* Members who desire to obtain the publications at a reduced rate must apply to the Director and not to the London Agents.

From the DIRECTOR, The Laboratory, Plymouth.
And from the London Agents: Messrs. DULAU & Co., 37, Soho Square, W.

VACATION COURSE IN MARINE BIOLOGY.

By arrangement with the Director of the Plymouth Laboratory of the
Marine Biological Association,

MR. WALTER GARSTANG, M.A., F.Z.S.,

Fellow and Lecturer of Lincoln College, Oxford,
and formerly Naturalist to the Marine Biological Association,

WILL CONDUCT A

COURSE OF STUDY
IN
MARINE BIOLOGY,

At the PLYMOUTH LABORATORY,

DURING THE EASTER VACATION, 1897,

From March 29th to April 24th.

Students who may desire to avail themselves of the opportunities that will thus be afforded for a practical study of the life and habits of marine organisms, and of the methods employed for their capture and preservation, should communicate in advance with

W. GARSTANG, Esq.,
Lincoln College, Oxford,

who will give any further information that may be required.

OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GUNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Professor LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence, the Association has erected at Plymouth a thoroughly efficient Laboratory, where naturalists may study the history of marine animals and plants in general, and where, in particular, researches on food fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent, for the use of a working table in the Laboratory, and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter. the payment of servants and fishermen, the hire and maintenance of fishing boats, and the salary of the Resident Director and Staff. At the commencement of this number will be found the names of the gentlemen on the staff. In no case does any one salary exceed £250.

The Association has received some £27,000, of which £12,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £7,000.

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS OF NEW SERIES, Vol. IV., No. 4.

PAGE

1. On the Peculiarities of Plaice from Different Fishing Grounds. By J. T. Cunningham, M.A. 315
2. The Oyster Culture of the Ancient Romans, *with Plate I.* By R. T. Günther, M.A. 360
3. Recent Reports of Fishery Authorities 366
4. Microscopic Marine Organisms in the Service of Hydrography. By Prof. P. T. Cleve 381
5. The Regulations of the Local Sea Fisheries Committees in England and Wales. By E. J. Allen, B.Sc. . . . 386
6. Contributions to Marine Bionomics. By Walter Garstang, M.A.
   - II. The Functions of Antero-Lateral Denticulations of the Carapace in Sand-burrowing Crabs 396
   - III. The Systematic Features, Habits, and Respiratory Phenomena of *Portumnus nasutus* (Latreille) 402
7. The Distribution of Marine Plankton 408
8. An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish. Revision of Tables. By E. W. L. Holt . . 410
9. Director's Report 415
10. Steamboat Fund—List of Subscribers 418

NOTICE.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for statements published in this Journal, excepting when those statements are contained in an official report of the Council.

TERMS OF MEMBERSHIP.

		£	s.	d.
Annual Members . . .	. per annum.	1	1	0
Life Members . . .	Composition Fee.	15	15	0
Founders . . .	. . .	100	0	0
Governors . . .	. . .	500	0	0

Members of the Association have the following rights and privileges; they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

All correspondence should be addressed to the Director, The Laboratory, Plymouth.

3 2044 093 366 730

Date Due

~~OCT 21 1950~~

FEB 14 1956